POWER

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Labor Omnia Vincit

LABOR conquers everything. Yes, more than that, Labor is everything —or everything is Labor. It is human labor that has converted the tree in the forest to the desk upon which I write. True, it was made mostly by machinery, but human labor made the machinery, too—and made the desk with it. The saw bench and planing machine are only its tools, just as are the handsaw and jack plane.

The difference between America today, with its cities and railroads, its farms and factories, its culture and civilization, and America as Columbus discovered it, is that it has had four and a quarter centuries of human labor expended upon it.

The only difference between a pocket of iron ore undiscovered in the heart of a mountain and a great engine turning the wheels of industry and doing the work of a multitude of men, is labor—human labor. The labor of the men who discovered and sunk the mine, of the men who won and transported the ore and converted it into iron and steel, of the men who invented and designed and made the engine and carried it and lined it up on its foundations and harnessed it to its work.

Not all of this is labor of hand and muscle. The adventure and knowledge of the prospector, the enterprise and effort of the financier, the ingenuity of the inventor, the study of the designer, the direction of the management of mine and blast furnace and rolling mill and railroad and engine works, the activities of the salesman, are there besides the skill and toil of the craftsman. And all these are different forms of human labor.

There are only three items that enter into the cost of a commodity or a service which are not resolvable into human labor—profit, interest and royalty, the last in the narrow sense of the money paid to one who has assumed or acquired the ownership of a natural resource and charges for it, as the Girard estate charges three dollars a ton for coal mined from its land.

Taxes are money paid for human labor. Instead of working on the road or taking our turn on the police force or in the legislature, we keep on at our jobs and pay, in taxes, somebody to do that work for us.

Insurance is money paid for human labor. In a simpler civilization a group of settlers might agree if one of their number lost his house or barn or stocks, to all contribute of their labor or its fruits to replace them. We do the same thing now through the insurance companies.

If all the comforts and conveniences and necessities of life are the fruits of human labor, it follows that the nation which will enjoy the most of these and live upon the highest plane with the least toil is that nation which uses its human labor to the best advantage and which makes the best use of the products of its labor.

And in the collective mind of that nation must stand out strong and clear that truth which was forced upon us in the time of war and is just as potent in the time of peace—that inefficiency and waste are economical crimes which will in the final analysis, affect their perpetrators, far from their consequences as they may think themselves to be.

F. R. Low

Analysis of Industrial Power

By H. GOODWIN, Jr.
Consulting Engineer, Philadelphia, Pa.

IN A PREVIOUS ARTICLE in *Power* it was shown that a division of the superpower staff was assigned to the study of the industries. It was the duty of this division to determine the feasibility and economy of the electrification of the industrial establishments within the Superpower Zone and the economies of fuel to be made thereby. By electrification in this case is meant the supply of power to the industrial establishments by the proposed superpower electrical system, co-operating with the present central stations. The words "feasibility" and "economy" cover not only fuel economy, but an actually lower operating cost for power to the industry. Therefore, all the work of this division and the facts and figures presented are of the greatest interest to all concerned with the operation of industrial establishments and the supply of industrial power.

When it is known that there are almost 100,000 industrial establishments in the Superpower Zone, with over three-quarters of that number using power, the magnitude of the proposition can be better appreciated. Much has been done on the determination of fuel rates, power costs, etc., and much data had been published on the subject. But when all these "leads" had been followed out, it was found in the end that practically all tests or records were incomplete in one or more important points, so that there was little more really known of over-all economies than there was in the middle nineties, when Horatio Foster studied the subject to determine if Niagara power was better than a competitor with the isolated steam plant. So it was determined that it would be necessary practically to build up new the analysis of industrial power and fuel.

Investigations based on latest census returns from the North Atlantic States (Superpower Zone) show more than 76,000 industrial plants, using in the aggregate over 9,000,000 hp., of which over 2,000,000 hp. is supplied by steam engines, 600,000 by steam turbines, 540,000 by water power, 279,000 by internal-combustion engines, and the remainder purchased power. Of those under 200 hp., 81 per cent purchase their power, whereas 78 per cent of those over 200 hp. generate their power.

All available total figures on the use of power and fuel in the states concerned were traced and led back to the 1914 Census of Manufacturers. Unfortunately, it was found that the records of the Fuel Administration and other war organizations could not be used. While the records may have been sufficient for the emergency and immediate purposes for which they were collected, they could not be used for accurate analytical purposes. The 1920 census covering the operating year of 1919 was in the process of collection. The Bureau of the Census was approached and replied that, with the co-operation of the Superpower Survey, they should be able to supply the information desired in time for use. Accordingly, E. F. Hartley, Chief Statistician for Manufacturers, with his staff, entered vigorously into the proposition. The results from the Census Bureau exceed original expectations and go beyond anything that had previously been done. The tables herewith presented show how the data have been tabulated in analytical form. Table I is a summary of the power and fuel used by the industrial establishments in the Superpower Zone. These are classified and divided into seventeen main groups, which are further subdivided into fifty-three subgroups. These cover the individual classifications of the Census Bureau, which number almost four hundred. The main groups follow standard groups of the Census Bureau, so that it is possible to get corresponding information very readily for this and previous censuses. The information for the different groups covers such items as employees, capital, value of products, value of materials and cost of fuel and purchase of power. A few of the groups may be explained:

2h. "Clothing" includes many small shops, but all engaged on work for the trade. Custom tailors are not included.

6b. "Manufacturers of Paper" includes such as paper bags, envelopes and paper boxes.

12b. "Cars, not by Railroads" are the independent car manufacturing plants, not the railroad shops engaged in the repair of cars and sometimes building a few. The latter are included in group 13a.

14a. "Miscellaneous Metal Work" is very similar to 3d. "All Other Iron and Steel Products," but is a small group of industries placed in group 14 for other reasons.

15. "Laundries" includes also cleaners and dyers.

17. "Government Institutions" includes the navy yards, arsenals, etc.

The columns under "Establishments" show that there are 95,984 manufacturing establishments in the Superpower Zone, of which 76,227, or 79 per cent use power. Most of the others use fuel. The average size of plant is based on those using power. The average size for all the industries is 119 hp., the individual averages varying from a minimum of 6 hp. for the clothing industry with its host of little shops, to 14,000 hp. average for the five large locomotive factories in the zone.

The "Power Supply Equipment" is divided into two main groups, "Prime Movers" and that "Operated by Purchased Energy." The subdivisions of the former are very clear, and the latter is supplied almost entirely electrically from central stations. Auxiliaries, such as boiler-feed pumps, etc., are not included under the prime movers. The average size of prime movers in most cases is remarkably low and for all the steam engines is only 128 hp. For turbines it is considerably higher, being 555 hp.

The "Waterwheels" show an average size of only 115 hp., which is quite a contrast to the large waterwheels to which we have now become accustomed in the central stations. The total horsepower of industrial waterwheels in the zone shows a decrease from census to census, due chiefly to the taking over of water powers by central stations and replacement of the small inefficient wheels with large economical units. The central-station operation of the waterpowers in this territory

TABLE I. INDUSTRIAL POWER AND FUEL SUMMARY FOR SUPERPOWER ZONE BY INDUSTRY GROUPS
Data from 1919 Census of Manufactures

TABLE I. INDUSTRIAL POWER AND FUEL SUMMARY FOR SUPERPOWER ZONE BY INDUSTRY GROUPS

Data from 1919 Census of Manufactures

Industry		Establishments			Power Supply Equipment											Fuel Used			
					Prime Movers											Coal			
							Steam Engines		Steam Turbines,		Internal Combustion Engines,		Water Wheels,						
Main Group	Sub-Group	Total No.	Using Power No.	Average Hp.	Aggregate Hp.	Total Hp.	No.	Hp.	No.	Hp.	No.	Hp.	No.	Hp.	Operated by Purchased Energy, Hp.	Anthracite Long Tons	Bituminous Short Tons	Total Equivalent Bituminous, Short Tons	Coke, Short Tons
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. Food and kindred products	*a.* Slaughtering	723	552	91	50,300	33,350	332	30,373	25	2,977	0	0	0	0	16,950	224,668	216,854	418,851	7,637
	b. Flour and grist mill products	1,221	1,217	48	58,115	45,588	175	11,605	4	165	240	5,471	1,045	28,347	12,527	25,103	21,112	43,680	84
	c. Bread and bakery products	8,547	5,598	11	62,377	18,556	140	15,053	11	2,486	139	995	8	22	43,821	472,851	114,109	539,319	76,963
	d. Sugar refining	13	13	2,700	35,041	35,041	229	23,678	22	11,363	0	0	0	0	0	406,248	865,118	1,231,118	180
	e. All other food products	4,891	4,085	44	179,351	99,549	1,489	85,533	50	2,637	640	9,326	82	2,053	79,802	386,956	485,502	833,774	5,514
2. Textiles and their products	*a.* Cotton goods, small wares and lace	689	676	1,320	895,513	713,879	772	418,783	121	151,550	32	1,974	662	141,572	181,634	307,780	1,683,664	1,952,065	16,426
	b. Knit goods	1,383	1,322	68	89,439	53,402	331	39,795	15	5,814	24	235	91	7,558	36,037	89,001	273,169	353,012	158
	c. Silk goods	1,190	1,158	120	139,061	80,052	379	59,771	34	12,159	41	1,327	56	6,795	59,009	258,569	188,958	421,214	383
	d. All woolen goods	636	623	610	380,229	317,237	694	170,621	79	100,934	15	962	427	44,720	62,992	181,512	1,210,117	1,373,486	1,994
	e. Carpets and rugs	70	65	490	31,999	25,704	72	20,582	6	3,750	2	85	7	1,287	6,295	36,323	225,452	258,087	300
	f. Dyeing and finishing	615	565	252	142,520	118,917	1,755	74,498	75	31,088	28	2,134	71	11,197	23,603	429,501	951,073	1,336,302	1,215
	g. All other fabrics and materials	313	292	356	104,078	81,169	233	47,744	19	13,667	11	466	76	19,292	22,909	129,176	173,350	289,543	18,502
	h. Clothing	14,638	13,024	6	83,914	26,597	243	21,509	8	2,265	179	1,608	23	1,215	57,317	279,219	130,146	380,301	9,348
	i. All other textiles	868	717	67	47,969	23,538	182	19,727	7	2,041	33	638	20	1,132	24,431	52,344	233,728	280,803	4,002
3. Iron and steel	*a.* Blast furnaces	27	27	6,800	183,833	183,395	255	85,844	10	23,020	39	74,405	4	126	438	40,516	273,454	309,754	3,170,821
	b. Steel works and rolling mills	112	112	5,100	571,666	489,943	1,147	353,920	138	75,341	25	59,747	8	935	81,723	521,271	3,549,059	4,018,206	88,698
	c. Locomotives, not by railroads	5	5	14,221	71,106	22,585	52	17,085	6	5,000	2	500	0	0	48,521	32,798	216,729	246,179	20,380
	d. All other iron and steel products	6,625	6,218	148	919,150	479,581	2,045	281,911	177	148,261	1,079	29,427	313	19,982	439,569	717,358	2,340,098	2,984,744	565,304
4 Lumber	*a.* Lumber	1,748	1,641	46	76,222	71,288	1,380	53,022	11	1,085	223	4,990	380	12,191	4,934	1,157	19,228	20,275	275
	b. Furniture and all other	3,872	3,069	66	204,311	135,117	1,113	118,263	18	4,385	334	4,957	211	7,512	69,194	85,324	325,738	402,568	10,881
5. Leather	*a.* Tanned, curried and finished	366	352	250	87,929	58,485	356	47,924	22	9,137	9	428	12	996	29,444	78,148	431,377	501,832	2,420
	b. Finished products	2,876	2,355	38	90,152	45,976	307	33,372	18	10,990	75	871	15	743	44,176	69,207	215,753	277,868	846
6. Paper and printing	*a.* Paper and wood pump	297	297	1,620	482,086	426,023	1,085	184,827	61	38,056	15	1,796	682	201,344	56,063	546,391	1,755,752	2,247,087	10,013
	b. Manufactures of paper	1,133	1,038	54	55,887	32,043	169	21,174	20	8,447	65	923	22	1,499	23,844	71,380	124,238	188,488	1,313
	c. Printing and publishing	9,460	6,956	24	168,456	31,710	221	27,860	7	697	339	2,466	24	687	136,746	147,488	74,426	206,096	1,852
7. Liquors and beverages		1,424	1,303	88	113,934	101,762	1,225	97,792	29	2,588	102	714	34	668	12,172	345,088	396,059	706,252	5,140
8 Chemicals and allied products	*a.* Coke, excluding gas-house coke	10	10	3,975	39,746	20,732	115	9,442	53	11,290	0	0	0	0	19,014	4,077	4,019,770	4,023,436	36,945
	b. Explosives	23	23	850	19,522	16,049	87	8,072	20	7,214	1	14	25	749	3,473	40,157	251,416	287,489	0
	c. Gas, illuminating and heating	265	202	540	108,197	103,792	1,331	75,472	404	25,290	33	3,016	1	14	4,405	1,229,102	2,399,383	3,502,208	608,629
	d. Petroleum refining	21	21	3,167	66,517	65,020	709	29,656	77	23,158	26	12,206	0	0	1,497	1,037,653	388,913	1,322,800	222,156
	e. All other chemicals	2,937	1,853	156	289,867	184,965	1,841	136,549	129	40,742	190	4,869	37	2,805	104,902	993,197	1,956,813	2,850,695	39,840
9. Stone, clay and glass	*a.* Cement	29	28	5,800	162,066	114,886	192	94,694	13	14,070	15	6,072	1	50	47,180	272,241	1,854,521	2,099,488	1,586
	b. All other stone products	1,724	1,257	60	76,304	41,351	689	34,945	5	1,982	402	4,102	6	322	34,953	96,186	283,909	370,152	53,438
	c. All clay products	694	593	158	93,602	67,292	646	61,550	5	1,125	88	1,905	33	2,712	26,310	176,312	738,238	896,209	6,622
	d. All glass products	435	326	40	13,046	5,822	77	3,755	2	200	36	1,827	2	40	7,224	12,245	231,173	242,179	6,591
10. Metals, non-ferrous	*a.* Metals, non-ferrous	696	606	490	297,209	195,826	286	97,691	71	93,355	91	2,460	21	2,320	101,383	796,475	979,697	1,696,802	329,395
	b. Metal products, non-ferrous	3,991	2,817	38	108,040	49,948	285	38,575	17	4,226	200	4,474	51	2,673	58,092	87,386	226,804	305,566	9,837
11. Tobacco manufactures		4,175	567	27	15,334	8,773	107	7,744	2	576	17	176	8	277	6,561	39,529	40,007	75,616	908
12. Vehicles	*a.* Automobiles	3,471	3,214	18	58,307	16,094	82	9,250	6	3,875	368	2,773	4	196	42,213	58,402	118,525	171,090	1,213
	b. Cars, not by railroads	11	11	2,057	22,628	5,398	19	4,890	1	500	2	8	0	0	17,230	38,471	82,928	117,480	8,744
	c. All other vehicles	823	637	23	14,445	6,730	53	4,445	2	56	128	1,083	27	1,146	7,715	10,796	26,832	36,535	622
13. R.R. repair shops	*a.* Steam railroad repair shops	215	189	530	100,344	67,744	366	61,141	14	6,150	22	358	2	95	32,600	421,705	599,943	979,477	205,085
	b. Electric railroad repair shops	154	127	153	19,562	805	18	805	0	0	0	0	0	0	18,757	14,161	30,439	43,166	1
14. Miscellaneous industries	*a.* Metal work	580	524	116	60,783	33,755	113	12,418	29	16,403	62	3,232	24	1,702	27,028	64,970	157,395	215,896	9,220
	b. Rubber goods	224	217	1,500	175,120	88,067	273	69,545	27	14,064	7	1,023	28	3,435	87,053	128,301	585,463	700,908	4,006
	c. Electrical machinery	574	544	414	225,195	122,113	172	42,640	33	76,393	39	1,810	10	1,270	103,082	97,087	495,539	583,677	10,676
	d. Ice manufactured	338	330	337	111,318	82,566	617	74,392	25	1,628	52	5,778	6	768	28,752	170,773	558,842	712,636	1,414
	e. Shipbuilding	393	350	655	229,078	57,478	233	29,022	23	26,196	167	2,213	2	47	171,600	34,222	496,429	527,226	55,447
	f. All other miscellaneous	7,802	5,968	45	270,030	162,131	1,183	119,592	52	31,215	352	5,514	122	5,810	107,899	349,629	748,382	1,061,959	19,273
15. Laundries		1,596	1,563	35	55,087	44,371	991	42,562	19	1,123	41	588	5	98	10,716	178,569	234,261	394,961	4,871
16. Mines and quarries	*a.* Anthracite coal mines	387	384	2,340	899,726	782,223	5,296	730,141	45	50,665	79	1,417	0	0	117,503	8,552,634	29,663	7,721,990	0
	b. Mines and quarries, except anthracite coal mines	643	555	200	111,031	75,050	1,156	64,286	12	3,466	133	5,577	17	1,721	35,981	45,833	236,127	277,382	328
17. Government institutions		31	31	3,350	102,729	77,534	59	30,328	36	46,196	4	100	3	910	25,195	24,375	403,649	425,586	3,532
Grand total		95,984	76,227	119	9,069,471	6,247,002	33,379	4,255,868	2,115	1,171,061	6,246	279,040	4,708	541,033	2,822,469	20,909,865	34,669,324	53,463,513	5,661,028

TABLE II. POWER AND FUEL USED BY ALL INDUSTRIES IN THE SUPERPOWER ZONE GROUPED BY PLANT SIZE
Data from 1919 Census of Manufactures

Plant Size, Hp	Establishments No.	Establishments Average Hp.	Power Supply Equipment: Aggregate Hp.	Prime Movers: Total Hp.	Steam Engines No.	Steam Engines Hp.	Steam Turbines No.	Steam Turbines Hp.	Internal Combustion Engines No.	Internal Combustion Engines Hp.	Waterwheels No.	Waterwheels Hp.	Operated by Purchased Energy, Hp.	Fuel Used: Coal: Anthracite, Long Tons	Coal: Bituminous, Short Tons	Coal: Total Equivalent Bituminous, Short Tons	Coke, Short Tons
No power	19,757	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	234,010	381,727	591,884	25,860
1-200	70,654	21	1,485,664	692,047	11,022	535,505	276	10,135	5,511	73,408	2,333	72,999	793,617	2,528,361	3,887,872	6,158,375	566,778
201-500	2,841	315	894,056	569,154	4,618	488,880	174	19,514	294	11,662	627	49,098	324,902	1,265,149	3,899,249	5,037,683	308,288
501 and above	2,732	2,450	6,689,751	4,985,801	17,739	3,231,483	1,665	1,141,412	441	193,970	1,748	418,936	1,703,950	16,882,346	26,498,476	41,675,571	4,760,102
Total power	76,227	119	9,069,471	6,247,002	33,379	4,255,868	2,115	1,171,061	6,246	279,040	4,708	541,033	2,822,469	20,675,855	34,287,597	52,871,629	5,635,168
Grand total	95,984	.....	9,069,471	6,247,002	33,379	4,255,868	2,115	1,171,061	6,246	279,040	4,708	541,033	2,822,469	20,909,865	34,669,324	53,463,513	5,661,028

TABLE III. POWER AND FUEL USED BY ALL INDUSTRIES IN THE SUPER POWER ZONE GROUPED BY CHARACTER OF POWER SUPPLY
Data from 1919 Census of Manufactures

Character of Power Supply / Plant Size Hp.	Establishments No.	Establishments Average Hp.	Power Supply Equipment: Aggregate Hp.	Prime Movers: Total Hp.	Steam Engines No.	Steam Engines Hp.	Steam Turbines No.	Steam Turbines Hp.	Internal Combustion Engines No.	Internal Combustion Engines Hp.	Water Wheels No.	Water Wheels Hp.	Operated by Purchased Energy, Hp.	Fuel Used: Coal: Anthracite, Long Tons	Coal: Bituminous, Short Tons	Coal: Total Equivalent Bituminous, Short Tons	Coke, Short Tons
No power	19,757	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	234,010	381,727	591,884	25,860
Steam Power Only																	
1-200	6,446	61	395,029	395,029	7,886	388,054	174	6,975	.....	.....	.....	.....	.....	855,337	1,886,507	2,655,485	149,745
201-500	949	322	305,909	305,909	2,380	291,745	118	14,164	.....	.....	.....	.....	.....	657,603	1,889,242	2,480,059	131,501
501 and above	912	2,210	2,017,858	2,017,858	7,357	1,437,942	790	579,916	.....	.....	.....	.....	.....	7,070,078	12,139,926	18,500,448	2,286,063
Sub-total	8,307	327	2,718,796	2,718,796	17,623	2,117,741	1,082	601,055	.....	.....	.....	.....	.....	8,583,018	15,915,675	23,635,992	2,567,249
Purchased Electric Power Only—																	
1-200	53,968	13	680,456	.....	.....	.....	.....	.....	.....	.....	.....	.....	680,456	1,091,594	965,127	1,943,805	338,435
201-500	681	303	206,611	.....	.....	.....	.....	.....	.....	.....	.....	.....	206,611	123,109	575,813	685,748	44,734
501 and above	367	1,620	596,240	.....	.....	.....	.....	.....	.....	.....	.....	.....	596,240	197,520	2,542,126	2,719,861	100,182
Sub-total	55,016	27	1,483,307	.....	.....	.....	.....	.....	.....	.....	.....	.....	1,483,307	1,412,223	4,083,066	5,349,414	483,351
All Other Power																	
1-200	10,240	40	410,179	297,018	3,136	147,451	102	3,160	5,511	73,408	2,333	72,999	113,161	581,430	1,036,238	1,559,085	78,598
201-500	1,211	314	381,536	263,245	2,238	197,135	56	5,350	294	11,662	627	49,098	118,291	484,437	1,436,194	1,871,876	132,053
501 and above	1,453	2,800	4,075,653	2,967,943	10,382	1,793,541	875	561,496	441	193,970	1,748	418,936	1,107,710	9,614,748	11,816,424	20,455,262	2,373,917
Sub-total	12,904	377	4,867,368	3,528,206	15,756	2,138,127	1,033	570,006	6,246	279,040	4,708	541,033	1,339,162	10,680,615	14,288,856	23,886,223	2,584,568
Total (power)	76,227	119	9,069,471	6,247,002	33,379	4,255,868	2,115	1,171,061	6,246	279,040	4,708	541,033	2,822,469	20,675,855	34,287,597	52,871,629	5,635,168
Grand total	95,984	.....	9,069,471	6,247,002	33,379	4,255,868	2,115	1,171,061	6,246	279,040	4,708	541,033	2,822,469	20,909,865	34,669,324	53,463,513	5,661,028

has a further advantage; the water power is usually sufficient to carry only part of the load of the central station, so that it will always have the demand to use all the water. The industrial, however, has two different non-coincident cycles—the hours of operation and the flow of water. Therefore the result in the case of the industrial is usually waste of water and necessity for stand-by power.

Returning again to Table I, under "Fuel Used," there is one heading that needs explanation. It is "Total Equivalent Bituminous Coal." The two columns before this show the anthracite and bituminous coal used. It is evident, however, that the proportions of these vary in the different groups. It is therefore necessary to reduce them to equivalent terms to have a basis of comparison. To do this, the many variables in the coals and boiler efficiencies were considered and it was decided that one long ton of anthracite as burned in the industries, is equivalent to 0.9 ton of bituminous coal. This factor was applied to the figures in column 17 and the result added to the corresponding figure in column 18 to give the total equivalent in column 19.

The total coal used in the zone is thus equivalent to 53,463,513 tons. Of this 7,500,000 tons is used for coke (8a) and gas (8c) and a large percentage thereby converted into other forms of fuel. The anthracite mines use 8,552,634 tons of their product directly for mining more coal. This is about 10 per cent of their total product. The small amount of bituminous coal that they use is mostly for the dredges that are pumping "river coal" from the streams.

Table II is the first introducing the special features of the census tabulation for superpower. Never before have data on power and fuel for plants in a large territory been grouped by plant size. First, the plants using no power are set off and it is seen that they consume just a little more than 1 per cent of the fuel. Then the plants using power are divided into three groups—those having a total capacity up to 200 hp., those having from 201 to 500 hp., and those having 501 hp. and more. The figures in this table are full of significance, and in order to visualize them better, the chief items are represented in the graphs Figs. 2 and 3. Fig. 3 shows that the great bulk of the plants are comparatively small, less than 200 hp. The plants above 500 hp. are comparatively few in number, and if another line were drawn at 5,000 hp., it would be found that the plants above that rating, which are likely to be advertised widely when built, are few in number.

Fig. 3 is particularly interesting as opposed to Fig. 2. Whereas, the latter shows the number of plants in each group, the former gives the total horsepower installed in each. The 3.5 per cent of the plants above 500 hp. account for 74 per cent of all the power. This figure in combination with Fig. 2, gives a good foundation for obtaining a proper perspective of the industrial power situation.

Horsepower Operated by

Horsepower of Prime Movers

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Coming back again to Table II, the column of "Total Equivalent Bituminous Coal" is an eye opener. It is common to hear "the uneconomical small plant" blamed for the general waste of fuel. These may be, and doubtless in many cases are, very wasteful. But the total consumption of coal by plants up to 200 hp. is only 11.5 per cent, and for the size from 201 to 500 hp. only 9.5 per cent, leaving 79 per cent for the plants above 500 hp. If half the coal in the plants less than 500 hp. were saved, there would be a decrease in the total consumption of only 10 per cent; while if the same proportionate economy were made in the large plants, the total consumption of coal would be reduced to but approximately 60 per cent of the present consumption.

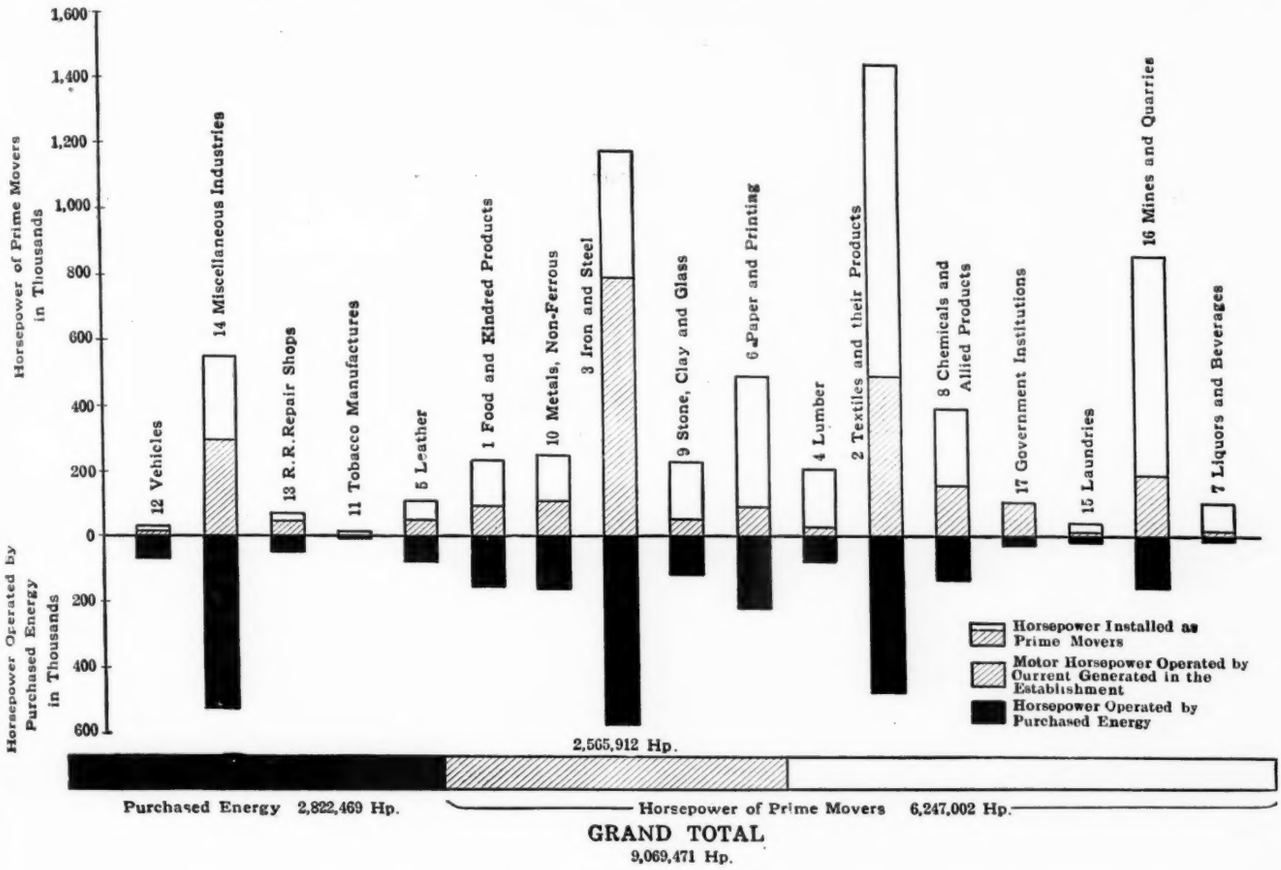


FIG. 1 SHOWING COMPARISON OF GENERATED TO PURCHASED POWER IN VARIOUS INDUSTRIES

Turning now to Table III, there is seen in summary form the data that were tabulated for each one of the 53 industry groups. Examination will reveal what an accurate analysis can be made of the fuel use for a particular industry, where the heating process and power requirements have comparatively fixed relations. This table was prepared by selecting out in two main groups the plants in which the items appear in simple terms and putting the remainder together under "All Other Power." The special groups are those plants operated by "steam power only" and those by "purchased electric power only." In each one of the groups the previous classification by plant size has also been used.

Looking at Table III for further details on Figs. 2 and 3, it appears that, of the great mass of small plants, 53,968, or 73 per cent of them, are relying on purchased electric power entirely.

But Table III and the detail tables for the industries were so arranged to give definite comparisons of the amounts of coal required in the different types and sizes of plants. The fourth line for plants using steam power only and above 500 hp. shows that 2,017,858 hp. required 18,500,448 tons of coal in one year, or an average of 9.2 tons per horsepower per year. Taking the corresponding plants using purchased electric power only, shows 596,240 hp. using 2,719,861 tons, or 4.6 tons per horsepower per year. While taking blanket figures like these, without allowing for the different processes in the different industries, may not be exactly correct, it still shows an average saving of 50 per cent of the fuel in the large plants. From this saving there of course must be deducted the coal that would be burned in the central station. For a large modern plant this may be assumed at 1 to 1½ tons per horsepower per year. Adding this to 4.6 tons required for heat and process, still leaves a saving of over 3 tons per horsepower per year.

This gives a lead to another important fact revealed by the table. Even though all the industries were supplied from central stations, there would still be a large amount of coal for the plant engineers to work with and economize. Taking the subtotal for "Purchased Electric Power" only, it is seen that plants aggregating 1,483,307 hp. of motor capacity require coal for heating and process to the extent of 5,349,414 tons. This is 3.6 tons per horsepower per year. Applying this figure to

the total of 9,069,471 hp. gives 33,000,000 tons out of the present 53,000,000 which would still be burned at the plants.

There are many more points in these tables that might be discussed, but it is hoped that sufficient have

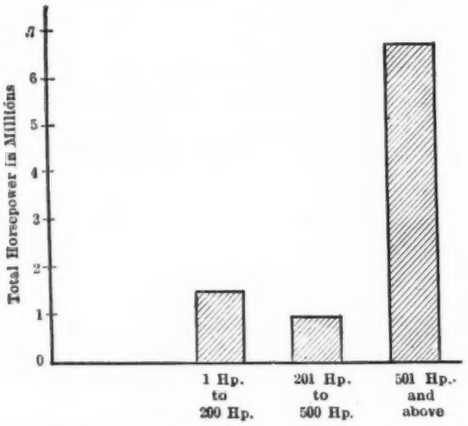


FIG. 2. POWER DISTRIBUTION ACCORDING TO PLANT CAPACITY

been explained so that the reader may be able to use them and apply them to his particular problems; also that an interest may have been aroused so that he will

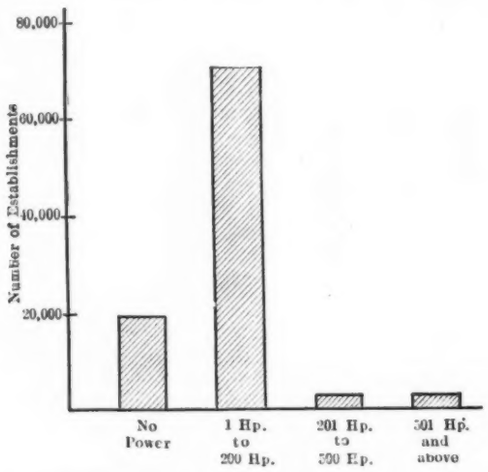


FIG. 3 SHOWING RELATION BETWEEN NUMBER OF PLANTS AND THEIR SIZE

better appreciate the report of the Superpower Survey when, in the near future, it is made available.

Notes on the Open Heater

BY J. R. BELKNAP

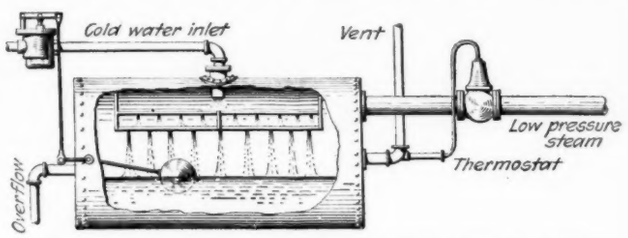
The main duty of an open heater is to heat the feed water. To this function has been added other duties, as the reduction of scale-forming matter that water may contain, and caring for insoluble matter that may settle or be filtered out. Calcium bicarbonate is reduced to the carbonate, CO_2 being given off in the reaction. The carbonate is only slightly soluble in hot water. Heaters that have large water-storage space and large filters are required to make this effective.

The elimination of air in the boiler-feed water is important. Water will dissolve about 1 per cent of its volume of oxygen at 50 deg. F. At the boiling point practically all the air is driven off. Unless the boiler is protected by scale, corrosion may be serious unless the water is deaërated.

In connection with the primary duty of heating the feed with low-pressure steam, we may consider the heater as a condenser. In condenser work it has been found that the air collects in pockets at low points in the air-steam space. Steam at 212 deg. weighs 0.037 lb. per cu.ft. Air at 212 deg. weighs 0.059 lb. per cu.ft., 60 per cent heavier than steam. CO_2 weighs about 0.090 lb. per cu.ft. So why not vent open heaters at the lowest practicable point in the air-steam space?

I once observed a heater that would heat the feed water until a certain amount of scale collected, then it would lose steam through the vent and the water temperature would drop. Changing the vent to a point near the overflow line permitted the heater to run until it was nearly clogged with scale before it would give trouble. I would not say that this was altogether advisable, but the war was on and we had other things to do besides clean the heater.

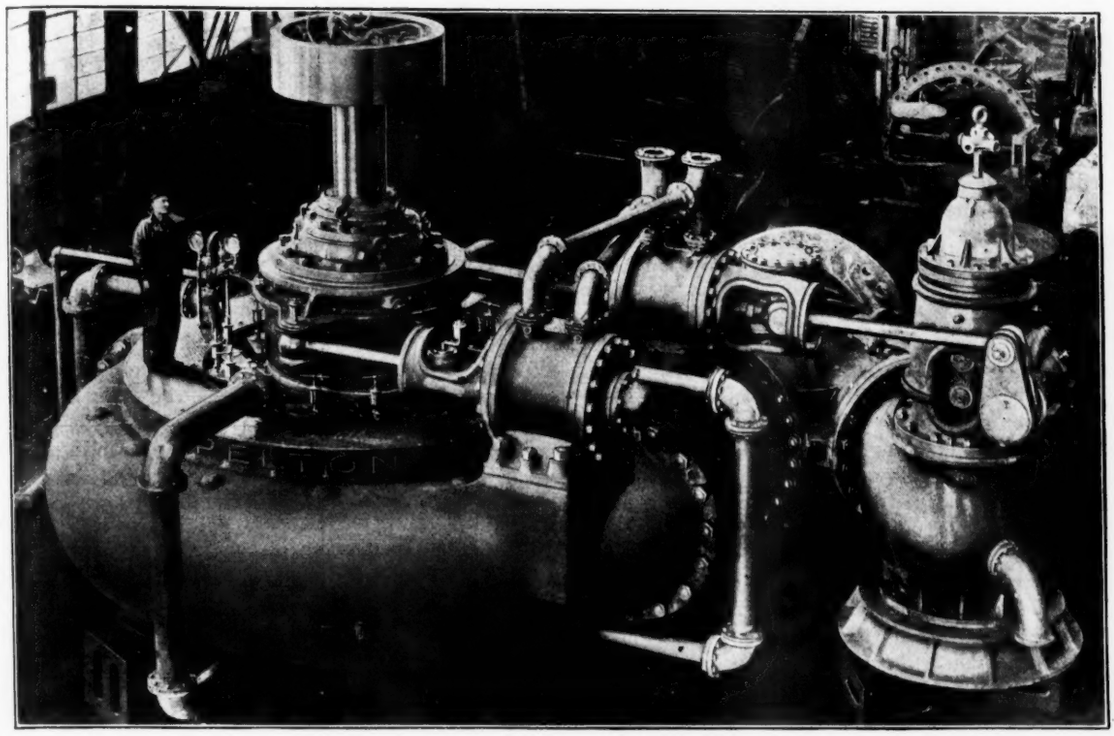
Control of the low-pressure steam supply is important. Manual control is usually wasteful and unsatis-



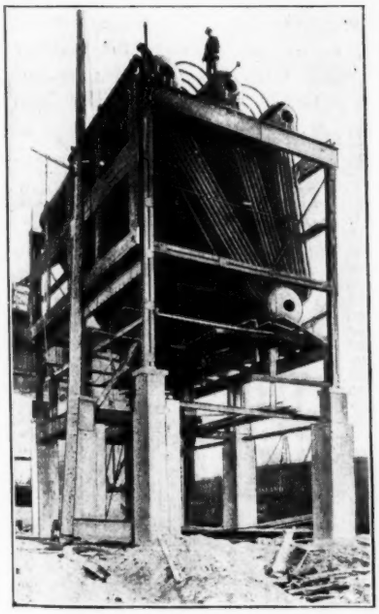
HEATER WITH THERMOSTAT-OPERATED VALVE

factory. A good thermostat-operated valve installed as indicated by the sketch, has given satisfactory results. The valve controls the low-pressure steam supply and is actuated by the thermostat which is installed in the vent. A deficiency of steam causes air to circulate around the thermostat, while an excess of steam quickly causes it to close the valve. I have had arrangements like this give feed-water thermometer charts that had the appearance of having been drawn with a compass, and without loss of steam. Serious trouble with leaking mud drums was almost entirely eliminated by keeping the feed water at 210 deg. within very close limits.

Of possible interest to some of *Power's* readers is the Second Special Coal Number of the *South African Mining and Engineering Journal* for July, published by the Argus South African Newspapers, Ltd., whose London office is at Byron House, 82-85 Fleet St., London, E. C. 4. This issue is a voluminous one, being of large size and containing over 200 text pages. It is understood that it may be obtained from the London office for 5 shillings. The main features of this number many be summarized as follows: The coal resources of South Africa, with maps, statistics, etc.; the collieries of the Transvaal, Orange Free State, Natal, Cape, Swaziland, Rhodesia and Portuguese East Africa; coaling facilities at Durban and Lourenco Marques; coal-mining machinery, coal cutters, hoisting and hauling machinery, electrical power plants, coal washing and sorting, ventilating appliances, pumps, trucks, etc.; byproducts plants; railway and shipping questions; projected new railways and ports to serve the expanding coal fields.



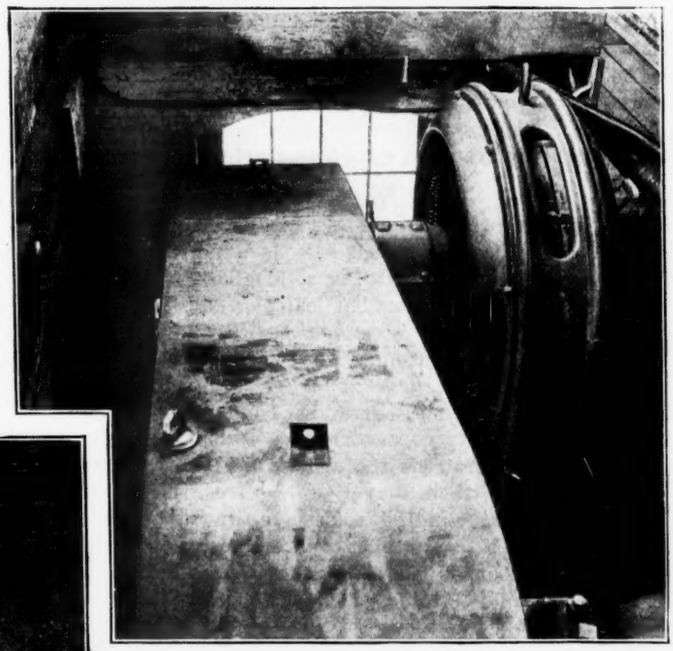
A 25,000-hp. reaction- or Francis-type water turbine that operates under an 800-ft. head. It is one of two at the Kern River No. 3 plant of the Southern California Edison Co. and is said to be the highest-head machine of its type ever built. An interesting feature of these turbines is that each has two runners, one for 500 r.p.m. and one for 600 r.p.m. The object of the different speeds is to enable the plant to deliver either 50- or 60-cycle current, which it must be prepared to do at short notice. It is said the runners can be changed in 20 hours. The plant was fully described in *Power* for June 21.



Nowadays it is often necessary, when putting up a new plant, to install the boiler before the building is erected, either because of cramped quarters or delayed shipments of structural steel. This picture shows a good example of the practice and also an unusually high setting.

The photograph at the right shows what happened when an engineer put crude oil in his boiler to prevent scale. The oil collected on the bottom and formed an insulating skin, preventing the water from absorbing heat from that part of the sheet. It then became so weakened by excess heat that the pressure bulged it out, and if the boiler had been kept in service there would have been a wreck instead of a temporary shutdown. The sheet was ½ in. thick., and the bulge was about 3½ ft. long and about 7 in. deep.

Right—a specially designed 200-kva. generator, driven through a 22-in. Link-Belt chain from a 250-hp. waterwheel shaft, was installed in this pit to take the place of steam power in a New England textile mill. The pit is only 8½ ft. wide and the center to center distance only 7½ ft., making necessary the narrow generator and the compact arrangement shown. The generator was supplied with three bearings and was mounted on a concrete foundation. The speed of the waterwheel is 120 r.p.m. and that of the generator 600 r.p.m.



Copper-Wire Properties and Requirements Governing Installation

By EDGAR P. SLACK
Assistant Engineer, Underwriters Laboratories, New York City

ON THE opposite page the table lists wires by sizes according to the Brown & Sharpe (B. & S.) gage, also called the American Wire Gage (A.w.g.), which is the gage principally used in electrical work in this country. The gage numbers range from 40 for a wire 0.00314 in. in diameter to 0000 for a wire having a diameter of 0.460 in. Wires smaller than No. 18 B. & S. gage are not used for circuit connections; Nos. 18 and 16 are used for fixture wiring and flexible cords; and No. 14 and larger are used for installation of electric circuits. For sizes above No. 0000 conductors are designated by their circular mil cross-section.

A mil is a thousandth of an inch, and is largely used as a unit of measurement for diameters of wires. Thus, a No. 12 wire has a diameter of 0.0808 in., that is, 80.8 thousandths of an inch; or more simply, 80.8 mils. The cross-section of wires might be figured in square inches, but can be much more conveniently computed in circular mils, which gives just as true a measure of the area but in different terms. To find the area of a given wire in circular mils, express its diameter in mils and square this number. For a No. 12 wire, the diameter being 80.8 mils, the cross-sectional area is 80.8×80.8, or approximately 6,530 circular mils. This agrees with the table, and the same method is true throughout.

The resistance of copper wire is influenced by the temperature, increasing about 1 per cent for a rise of 4.5 deg. F. The table gives the resistance at 68 deg. F., this value being frequently used as a reference value.

Stranding of Cables

Solid diameters for conductors are given in the table and are useful for reference, but as a matter of fact wires are seldom manufactured solid above No. 0. The larger sizes, generally called cables, and often the smaller sizes also, are stranded for flexibility. For conduit work the National Electrical Code requires wires of No. 6 B. & S. gage or larger to be stranded so as to make them flexible. Stranded conductors are generally built up with a concentric lay, by using one wire as a central core and twisting around it six wires forming the first layer, then a layer of 12 wires, then 18, 24, 30, 36 wires, etc., winding each layer in the opposite direction from the preceding. While the exact stranding used by different manufacturers varies somewhat, the typical stranding table given is generally representative of common practice. To find the circular mils of a stranded conductor, find the circular mils for one strand and multiply by the number of strands. Flexible conductors, used as flexible cords, are made with more strands than stranded conductors, which are intended for fixed-circuit wiring.

In addition to the typical stranding described in the foregoing, another style, known as standardized stranding, is used, Table I. In this construction the individual strands are mostly B. & S. gage sizes, this stranding having been adopted during the war as a conservation measure. The cross-sections of the completed cables do not conform to standard B. & S. gage sizes, and therefore different carrying capacities have been assigned in the Code, as shown in Table I.

On account of the twist in the strands the weight of a stranded conductor is greater than of the equivalent solid wire, and the resistance is also greater, the increase being generally considered as about 2 per cent for both weight and resistance.

To prevent injury to wires while they are being drawn into conduit, the Code specifies the minimum size of conduit permitted for various numbers of wires, as noted in Table II. As a general rule the conduit should have a cross-section at least 2.5 times the sum of the cross-sections of the insulated wires. For sizes not greater than No. 10 B. & S. gage one more conductor than indicated in the table may be installed in the conduit, under special conditions described in the footnote. It should also be noted that "except in the case of stage pocket and border circuits the same conduit must not contain more than four two-wire or three three-wire circuits of the same system, except by special permission, and must never contain circuits of different systems." For conductors installed in vertical risers the Code specifies that the cables shall be supported within the conduit system by approved methods and at certain distances, which are noted in Table II.

The carrying capacities given in Table II are those permitted by the Code, being such that the heating produced will not appreciably deteriorate the insulation. Varnished-cloth insulation being less affected by heat than rubber, wires so covered are allowed to carry more current; and for other insulations, including weatherproof and slow-burning, the capacity is further increased.

TABLE I. STANDARDIZED STRANDING FOR COPPER WIRE

Strands			Cable		Allowable Carrying Capacity, Amperes		
No. of Strands	Dia. in Mils.	B. & S. Gage No.	Area in Circ. Mils.	Outside Dia., Bare, In.	Rubber Covered (A)	Varnished Cloth (B)	Other Insulations (C)
127	128	8	2,097,000	1.660	1,100	1,300	1,700
127	114	9	1,660,000	1.480	900	1,100	1,460
91	128	8	1,502,000	1.410	850	1,020	1,350
91	114	9	1,191,000	1.250	725	870	1,125
61	128	8	1,007,000	1.150	650	780	1,000
61	121	*	893,100	1.090	600	720	900
61	114	9	788,500	1.030	550	660	825
61	107	*	698,000	0.963	500	600	750
61	102	10	633,300	0.918	475	565	700
37	116	*	484,300	0.798	400	480	600
37	102	10	381,200	0.714	325	390	500
37	97	*	347,500	0.679	300	360	450
37	91	11	306,400	0.637	275	330	400
19	114	9	248,700	0.570	250	300	350
19	107	*	217,500	0.540	225	270	325
19	91	11	157,300	0.455	175	210	250
19	81	12	124,900	0.405	150	180	210
19	72	13	98,380	0.360	125	150	175
19	64	14	78,030	0.320	100	120	150
7	102	10	72,680	0.306	90	110	130
7	91	11	58,000	0.273	80	95	110
7	81	12	45,710	0.253	70	85	90
7	64	14	28,740	0.192	50	60	70
7	51	16	18,080	0.153	35	40	50
7	40	18	11,370	0.120	25	30	35
7	32	20	7,150	0.096	20	25	25
7	25	22	4,490	0.075	15	18	20

* These individual strands are odd sizes, not listed in B. & S. wire table.

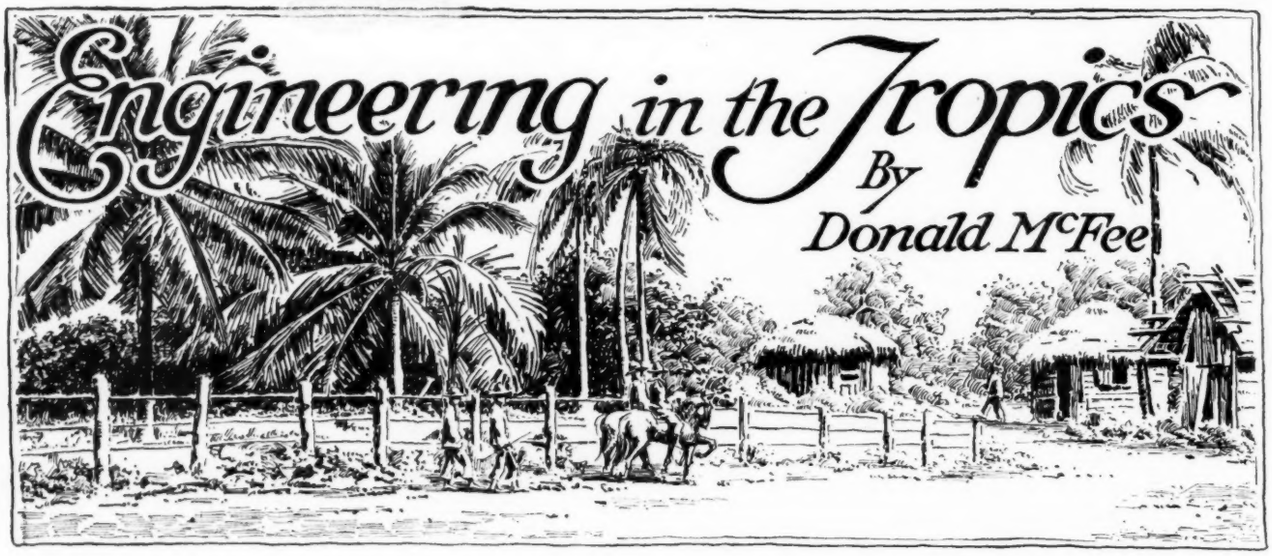
The question of voltage drop is not covered by Underwriters' rules. Table II shows the voltage drop along 1,000 ft. of wire when rated current is flowing.

The over-all diameter and total weight of insulated conductors vary considerably among different manufacturers, and the values in the table should be regarded as approximate only. For ordinary wiring purposes wire is single-braided below No. 6 B. & S. gage and is double-braided for No. 6 and larger sizes.

TABLE II. COMMERCIAL COPPER WIRES AND METAL CONDUITS, THEIR PROPERTIES AND SOME REQUIREMENTS GOVERNING INSTALLATION

B. & S. Gage No.	Area in Circular Mils = (Dia. in Mils)²	Diameter in Mils = √Circ. Mils (Solid)	Resistance, Ohms at 68 Deg. F.		Weight Bare, Lb.		Typical Cable Stranding			Required Size of Conduit, Two-Wire and Three-Wire Systems †									Distance Between Supports in Vertical Risers, Ft.	Rubber Insulation (A)				Varnished-Cloth Insulation. (B) ‡				Other Insulation (C)	
			Per 1,000 Ft.	Per Mile	Per 1,000 Ft.	Per Mile	No. of Strands	Dia. in Mils.	Outside Dia., Bare, In.	No. of Conductors in One Conduit										Allowable Carrying Capacity, Amperes	Volts Drop per 1,000 Ft. at Rated Current	600 Volts			Allowable Carrying Capacity, Amperes	Volts Drop per 1,000 Ft. at Rated Current	600 Volts		Allowable Carrying Capacity, Amperes	Volts Drop per 1,000 Ft. at Rated Current
										1	2	3	4	5	6	7	8	9										
										Minimum Size of Conduit, Elec. Trade, Size, In.												One Braid								
																						Approx. Over-all Dia., In.	Approx. Weight per 1,000 Ft. Complete, Lb.	Two Braids						
																								Approx. Over-all Dia., In.	Approx. Weight per 1,000 Ft. Complete, Lb.					
....	2,000,000	1,414	0.0052	0.0274	6,100	32,200	127	125.5	1.632	3	5	6	....	....	....	....	....	....	35	1,050	5.5	2.02	6,950	2.14	7,050	1,260	6.6	2.02	6,850	2.14	6,950	1,670	8.7	2,000,000
....	1,900,000	1,378	0.0055	0.0290	5,796	30,600	127	122.3	1.590	3	5	6	....	....	....	....	....	....	35	1,010	5.6	1.98	6,650	2.10	6,750	1,210	6.7	1.98	6,450	2.10	6,550	1,610	8.9	1,900,000
....	1,800,000	1,342	0.0058	0.0306	5,490	29,000	127	119.1	1.548	3	5	6	....	....	....	....	....	....	35	970	5.6	1.93	6,300	2.05	6,400	1,160	6.7	1.93	6,100	2.05	6,200	1,550	9.0	1,800,000
....	1,700,000	1,304	0.0062	0.0327	5,186	27,400	91	136.7	1.504	3	5	6	....	....	....	....	....	....	35	930	5.8	1.88	5,950	2.00	6,050	1,120	6.9	1.88	5,700	2.00	5,800	1,490	9.2	1,700,000
....	1,600,000	1,265	0.0065	0.0343	4,880	25,800	91	132.6	1.459	2½	5	6	....	....	....	....	....	....	35	890	5.8	1.84	5,650	1.96	5,750	1,070	7.0	1.84	5,400	1.96	5,500	1,430	9.3	1,600,000
....	1,500,000	1,225	0.0070	0.0369	4,576	24,200	91	128.4	1.412	2½	4½	5	6	....	....	....	....	....	35	850	6.0	1.79	5,300	1.91	5,400	1,020	7.1	1.79	5,000	1.91	5,100	1,360	9.5	1,500,000
....	1,400,000	1,183	0.0075	0.0396	4,270	22,500	91	124.0	1.364	2½	4½	5	6	....	....	....	....	....	35	810	6.1	1.74	5,000	1.86	5,100	970	7.3	1.74	4,700	1.86	4,800	1,290	9.7	1,400,000
....	1,300,000	1,140	0.0084	0.0443	3,963	20,900	91	119.5	1.315	2½	4½	5	6	6	....	....	....	....	35	770	6.5	1.68	4,650	1.80	4,750	920	7.7	1.68	4,400	1.80	4,500	1,220	10.2	1,300,000
....	1,200,000	1,095	0.0088	0.0464	3,660	19,300	91	114.8	1.263	2½	4½	6	6	6	....	....	....	....	35	730	6.4	1.63	4,300	1.75	4,400	880	7.7	1.63	4,050	1.75	4,150	1,150	10.1	1,200,000
....	1,100,000	1,048	0.0095	0.0501	3,356	17,700	91	109.9	1.209	2½	4	4½	6	6	....	....	....	....	35	690	6.6	1.57	4,000	1.69	4,100	830	7.9	1.57	3,750	1.69	3,850	1,080	10.3	1,100,000
....	1,000,000	1,000	0.0105	0.0555	3,050	16,100	61	128.0	1.152	2	4	4	5	6	6	....	....	....	35	650	6.8	1.50	3,650	1.62	3,750	780	8.2	1.50	3,400	1.62	3,500	1,000	10.5	1,000,000
....	950,000	974.7	0.0111	0.0586	2,898	15,300	61	124.8	1.122	2	4	4	5	6	6	....	....	....	35	625	6.9	1.48	3,450	1.60	3,550	750	8.3	1.48	3,250	1.60	3,350	960	10.7	950,000
....	900,000	948.7	0.0117	0.0617	2,745	14,500	61	121.5	1.093	2	3½	4	4½	5	6	6	....	....	35	600	7.0	1.46	3,300	1.58	3,400	720	8.4	1.46	3,100	1.58	3,200	920	10.8	900,000
....	850,000	922.0	0.0124	0.0655	2,593	13,700	61	118.0	1.062	2	3½	4	4½	5	6	6	6	....	35	575	7.1	1.42	3,150	1.54	3,250	690	8.6	1.42	2,950	1.54	3,050	880	10.9	850,000
....	800,000	894.4	0.0131	0.0691	2,440	12,900	61	114.5	1.031	2	3½	4	4½	5	6	6	6	....	35	550	7.2	1.38	3,000	1.50	3,050	660	8.6	1.38	2,800	1.50	2,850	840	11.0	800,000
....	750,000	866.0	0.0140	0.0739	2,288	12,100	61	110.9	0.997	2	3½	4	4½	5	6	6	6	....	40	525	7.4	1.35	2,800	1.47	2,850	630	8.8	1.35	2,650	1.47	2,700	800	11.2	750,000
....	700,000	836.7	0.0150	0.0792	2,135	11,300	61	107.1	0.964	2	3½	4	4½	5	6	6	6	....	40	500	7.5	1.32	2,650	1.44	2,700	600	9.0	1.32	2,450	1.44	2,500	760	11.4	700,000
....	650,000	806.2	0.0168	0.0886	1,983	10,500	61	103.2	0.929	2	3½	4	4½	5	6	6	6	....	40	475	8.0	1.28	2,500	1.40	2,550	570	9.6	1.28	2,300	1.40	2,350	720	12.1	650,000
....	600,000	774.6	0.0175	0.0923	1,830	9,660	61	99.2	0.892	2	3	3½	4	4½	5	6	6	....	40	450	7.9	1.24	2,300	1.36	2,350	540	9.5	1.24	2,100	1.36	2,150	680	11.9	600,000
....	550,000	741.6	0.0191	0.101	1,678	8,860	61	95.0	0.854	1½	3	3½	4	4½	5	6	6	6	40	425	8.1	1.19	2,100	1.31	2,150	510	9.7	1.19	1,950	1.31	2,000	640	12.2	550,000
....	500,000	707.1	0.0210	0.111	1,525	8,050	37	116.2	0.814	1½	3	3½	4	4½	5	6	6	....	50	400	8.4	1.13	1,900	1.25	1,950	480	10.1	1.13	1,750	1.25	1,800	600	12.6	500,000
....	450,000	670.8	0.0234	0.124	1,373	7,250	37	110.3	0.772	1½	3	3	3½	4	4½	5	6	....	50	365	8.5	1.08	1,700	1.20	1,750	435	10.2	1.08	1,550	1.20	1,600	550	12.9	450,000
....	400,000	632.5	0.0263	0.139	1,220	6,440	37	103.9	0.727	1½	2½	3	3½	4	4½	5	6	....	50	325	8.5	1.02	1,500	1.14	1,550	390	10.3	1.02	1,400	1.14	1,450	500	13.2	400,000
....	350,000	591.6	0.0300	0.158	1,068	5,640	37	97.2	0.680	1½	2½	3	3½	4	4½	5	6	....	60	300	9.0	0.97	1,350	1.08	1,400	360	10.8	0.97	1,250	1.08	1,300	450	13.5	350,000
....	300,000	547.7	0.0350	0.185	915	4,830	37	90.0	0.630	1½	2½	3	3½	4	4½	5	6	....	60	275	9.6	0.92	1,180	1.01	1,230	330	11.6	0.92	1,080	1.01	1,130	400	14.0	300,000
....	250,000	500.0	0.0420	0.222	762	4,020	37	82.1	0.575	1½	2½	3	3½	4	4½	....	....	....	60	250	10.5	0.85	980	0.94	1,030	300	12.6	0.85	900	0.94	950	350	14.7	250,000
0000	211,600	460.0	0.0497	0.262	645	3,400	19	105.5	0.528	1½	2	2½	3	3½	4	....	....	....	80	225	11.2	0.77	810	0.86	850	270	13.4	0.77	750	0.86	790	325	16.2	0000 B.&S.
000	167,800	409.6	0.0625	0.330	513	2,710	19	94.1	0.471	1	2	2½	3	3½	4	....	....	....	80	175	10.9	0.71	680	0.80	720	210	13.1	0.71	630	0.80	670	275	17.2	000
00	133,100	364.8	0.0789	0.416	406	2,140	19	83.7	0.419	1	2	2	2½	3	3½	4	....	....	80	150	11.8	0.67	550	0.75	590	180	14.2	0.67	500	0.75	540	225	17.8	00
0	105,500	324.9	0.0995	0.525	322	1,700	19	74.6	0.373	1	1½	2	2	2½	3	3	4	....	100	125	12.4	0.62	450	0.70	490	150	14.9	0.62	410	0.70	450	200	19.9	0
1	83,690	289.3	0.1258	0.663	255	1,346	19	66.3	0.332	1	1½	1½	2	2½	2½	3	3	4	100	100	12.6	0.57	370	0.62	390	120	15.1	0.57	330	0.62	350	150	18.9	1
2	66,370	257.6	0.1579	0.833	203	1,072	7	97.5	0.293	1	1½	1½	2	2	2½	2½	3	3	100	90	14.2	0.50	290	0.54	305	110	17.4	0.50	260	0.54	275	125	19.7	2
3	52,630	229.4	0.2004	1.059	160	845	7	86.6	0.260	1	1½	1½	2	2	2	2½	2½	3	100	80	16.0	0.47	245	0.52	260	95	19.0	0.47	225	0.52	240	100	20.0	3
4	41,740	204.3	0.2525	1.333	127	671	7	77.1	0.231	1	1½	1½	1½	2	2	2	2½	2½	100	70	17.7	0.44	200	0.49	215	85	21.5	0.44	185	0.49	200	90	22.7	4
5	33,100	181.9	0.3130	1.653	100	528	7	68.8	0.206	1	1½	1½	1½	1½	2	2	2	2	100	55	17.2	0.41	170	0.46	180	65	20.3	0.41	155	0.46	165	80	25.0	5
6	26,250	162.0	0.394	2.080	79.46	419.5	7	61.2	0.184	1	1½	1½	1½	1½	1½	2	2	2	100	50	19.7	0.39	140	0.43	150	60	23.6	0.39	125	0.43	135	70	27.6	6
8	16,510	128.5	0.641	3.388	49.98	263.9	7	48.4	0.145	1	1	1	1½	1½	1½	1½	1½	2	100	35	22.4	0.32	90	0.36	100	40	25.6	....	....	....	....	50	32.0	8
10	10,380	101.9	1.010	5.333	31.43	166.0	7	38.6	0.116	1	1	1	1	1½	1½	1½	1½	1½	100	25	25.3	0.27	63	0.30	69	30	30.3	....	....	....	....	30	30.3	10
12	6,530	80.8	1.601	8.453	19.77	104.4	7	30.6	0.092	1	1	1	1	1	1½	1½	1½	1½	100	20	32.0	0.24	47	0.28	53	25	40.0	....	....	....	....	25	40.0	12
14	4,107	64.1	2.565	13.54	12.43	65.6	7	24.2	0.073	1	1	1	1	1	1	1	1	1½	100	15	38.5	0.22	35	0.26	42	18	46.2	....	....	....	....	20	51.3	14
*16	2,583	50.8	4.040	21.33	7.82	41.3	7	19.3	0.058	....	....	....	....	....	....	....	....	....	6	....	0.16	18	....	....	....	....	....	....	....	....	....	10	....	16
*18	1,624	40.3	6.567	34.67	4.92	26.0	7	15.1	0.045	....	....	....	....	....	....	....	....	....	3	....	0.14	13	....	....	....	....	....	....	....	....	....	5	....	18

*Wires smaller than No. 14 B. & S. gage are not permitted, except for fixture work and flexible cords. †For sizes not greater than No. 10 B. & S. gage, one more conductor than indicated in above table may be installed in the specified conduit, provided the conduit is not longer than 30 ft. and has not more than the equivalent of two quarter bends from outlet to outlet, the bends at the outlets not being counted. Except in the case of stage pocket and border circuits the same conduit must not contain more than four two-wire or three three-wire circuits of the same system, except by special permission, and must never contain circuits of different systems. ‡Varnished-cloth Insulated wires smaller than No. 6 B. & S. gage may be used only by special permission from the Inspection Department. §For conduit work the National Electrical Code requires wires of No. 6 B. & S. gage or larger to be stranded so as to make them flexible. While the exact stranding used by different manufacturers varies somewhat, the typical stranding table given is generally representative of common practice. On account of the twist in the strands the weight of a stranded conductor is greater than of the equivalent solid wire, and the resistance is also greater, the increase being generally considered as about 2 per cent for both weight and resistance.



AFTER the collapse of an ill-considered venture in Honduras, I had worked my way southward and finally landed, through the kindliness of a coast schooner, in Santa Cristo. Venturing into a low odorous building labelled on the outside with the title "Hotel La Grande," I laid claim to the privilege of spending one night—maybe many nights—as its guest. While seated outside on a comfortable native bench, I watched the sun disappear and night fall swiftly as it does in tropical countries. Here and there within the shack hotel kerosene lamps made their appearance, over which I idly wondered since I had observed electric light globes suspended from the ceiling of the rooms. Evidently hotel business was not paying, and the "juice" had been cut off. Turning to the occupant of the adjoining bench I inquired the why of no electric lights. The most I gained was a shrug or two and an expression, by no means polite, concerning "La Plante electric."

Next day, being on the lookout for a job, I strolled down to the electric plant, which was at the edge of the town at the side of a small river. The outer appearance of the plant did not indicate any high order of machinery within, the walls composed of planking being askew, and the roof apparently about ready to collapse. Drifting to the open door I beheld a portly American in white directing, or striving to direct, the efforts of about a score of natives who were getting in each other's way and accomplishing but little.

The building contained two engines of the oil burning type, one being a small two-cylinder vertical machine while the other and larger one was a single cylinder horizontal engine of 100 horsepower. A motor-driven ice machine was also in the plant, as I afterwards discovered. Apparently the engineer, who was a big black Jamaican negro, had pulled the piston and for some reason was unable to get it back into place. It was evident that the wiper ring at the inner end of the piston had gotten caught in one of the exhaust ports, locking the piston. After watching the confusion awhile, I stepped in and inquired of the American, who was apparently the owner, the cause of the big noise. It seemed that the engine had failed to run the night before and if juice wasn't turned on at dark the company stood to lose its franchise, which specified that electric current could not be cut off for two successive nights. I suggested that he evidently needed an engineer, but he assured me that Jim the negro was a first-class man. I left and strolled around a few hours before returning to the plant. I had sized up that plant as being my meal ticket as long as I stayed in Santa Cristo, and I wanted to get back at what the college professor terms the "psychological moment." Four o'clock found me back at the leaning post at the door. The owner, who was now about ready to have apoplexy, called me in and told me if I wanted a job to "kick in."

It didn't take long to unbolt the exhaust flange, insert a bar and unlock the piston ring. The men pulled the piston out and I had Jim turn the ring so the joint was at the top and insert a small dowell to keep the ring from turning. One of the exhaust bridge ports had

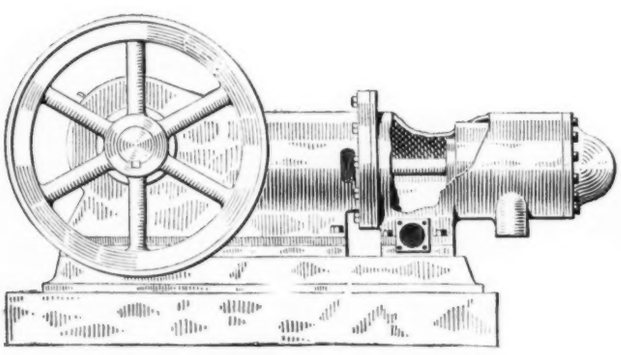


FIG. 1. WRECKED ENGINE CYLINDER

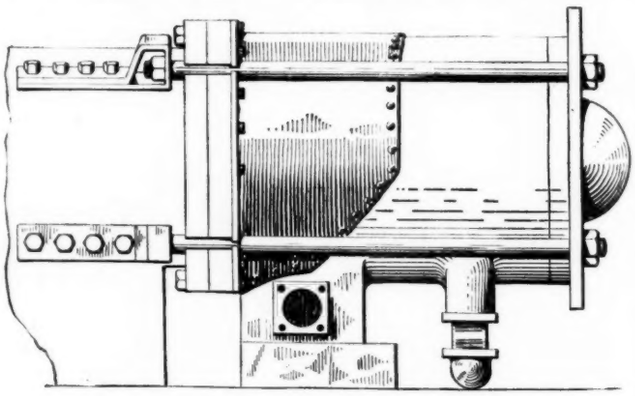


FIG. 2. METHOD OF REPAIRING FRACTURE

been broken off, allowing the ring ends to catch in the port.

By united efforts the engine was put together and ready to start at seven o'clock. Jim heated the hot head, the engine being a semi-Diesel, and got it turning over and finally the juice on. My position was still of an uncertain status; I certainly had no desire to supplant Jim in his job of fighting the engine in its present run-down shape—on the other hand I did need the money. After things were going well the owner and I adjourned to the La Grande and talked things over. He was, so he informed me, in Santa Cristo on a hurried trip; his manager had taken French leave with the bank account. He intended to return to the States, where he had secured new engines to replace the present wreck. He wanted me to stay and oversee the plant and lines until his return—that sounded like a six months hotel bill at least, and I agreed.

In a few days the owner left on a coaster to catch a fruit company's boat and I was left as sole manager of the choicest collection of junk ever gotten together. Jim didn't take kindly to me, as he had always run the plant as he saw fit. No doubt a good deal of our trouble was due to Jim's fall from authority as well as his natural aptitude to do the wrong thing at the critical moment. The next night the big engine wrecked herself. An explosion evidently took place in the air compression chamber, breaking the cylinder as shown in Fig. 1. Fortunately we were able to get the small unit started and by lighting half the town for three hours and switching over and lighting the other half for a similar period we escaped the franchise forfeiture penalty. The ice machine could only be run day times and the ice output was considerably reduced.

The matter of repairing the big engine was of serious moment. It was absolutely necessary to get it

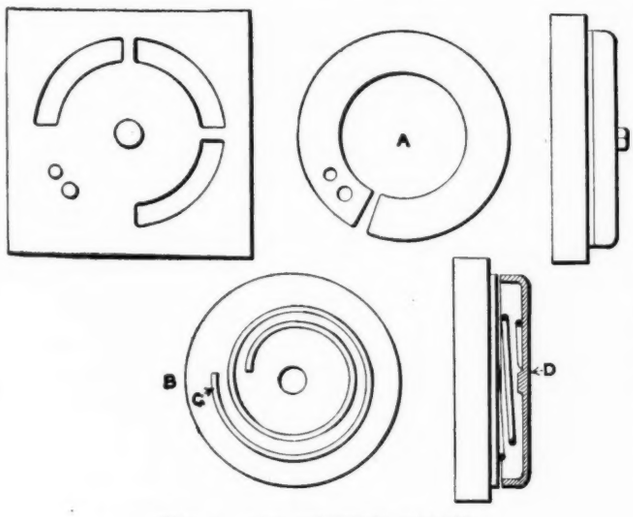


FIG. 3. AIR SUCTION VALVE

into service, and to secure a new cylinder from England meant a wait of months. To make things worse no machine shop was nearer than a hundred miles or so, while the plant possessed only a little 10-in. lathe, a drill press, and a blacksmith forge, although there was a fair supply of drills, etc., but no lathe tools. Studying the matter over I decided to cover the break with a steel plate. Rustling around the town I found a piece of -in. boiler plate down at the wharf, which we heated and sledged into the required shape. The plate was drilled, and fastened to the cylinder with cap screws as shown in Fig. 2, using a thin rubber gasket. Running out of cap screws we threaded iron plugs and after screwing them in riveted the heads. While the plate would hold the 5 or 6 lb. air pressure, it was entirely too light to bear the working stresses. Four bolts, 2 in. in diameter, were fastened to the frame by wrought iron

FIG. 4. REPAIR OF CYLINDER

straps and, extending to the end of the cylinder, were passed through holes drilled in a wrought iron ring that we made. Drawing up on the bolts relieved the cylinder of the working stresses. In operation the engine ran quite well and pulled its load until a new cylinder was secured. It must not be assumed that this job was an easy one. Trying to cut threads on a worn out lathe with a reforged chisel as the cutting tool, or welding a 2- by 3-in. iron ring, is not child's play, especially with the thermometer hanging around 110 degrees.

This hurry-up job about finished me, and consequently the next few days were spent mostly in the shade, sampling various colored things that came in glasses half filled with ice. My biggest job during this period was to keep Jim awake at night. The engine used a water drip to keep the cylinder cool on heavy loads. Jim had grown accustomed to leaning his chair against the generator frame and dropping off to a nice little nap. If the load dropped off the amount of water injection would cool the engine to such an extent as to cause the speed to drop. The dimming of the station lights would then cause Jim to wake up. After midnight Jim slept most of the time. The only way to stop this trouble was to discharge Jim or hire a helper to keep him awake. By promising an increase in pay to the helper if he kept Jim awake for a week, the latter began to sleep day-times. Usually I was saved from paying the bonus by having the helper and Jim both go to sleep on Saturday night. By hiring a new man occasionally things went along in a high-grade Central American way.

One Sunday night some time later the engine quit working about nine oc'clock. Inasmuch as Sunday is the big day in the Spanish speaking countries and is often celebrated with a big dance at night, this failure of the plant was serious. On other nights it was merely a nuisance to the citizens, but on Sunday night it could be termed a calamity. Rushing to the plant, I found Jim standing around in a helpless fashion. The air check valve *A*, Fig. 3, had broken. This valve was a spring steel ring and of course no extras were kept in stock. At first we were at a loss as to what to do. No similar steel could be secured, nor could one be made with the

slender facilities we had. As a last resort I took one of Jim's leather sandals and cut a circular piece *B* out of the sole. This was placed on the valve seat and reinforced with a light spiral spring, made of brass wire, which was held in place by the guard *D*. Outside of a tendency of the leather to cup, which was corrected by placing a circular piece of copper sheet on top of it, the valve ran as well as did the original one.

Troubles, especially those of a scrap-pile power plant, always come in groups. So in our plant. The power of the big engine had been decreasing for some time and the exhaust carried a lot of water. Jim claimed that the water drip was open just enough to keep the engine from pounding. I was at a loss to account for the drop in power so had the men pull the piston. As soon as this was removed the source of trouble was at once apparent. A crack in the cylinder, Fig. 4, extended to the exhaust ports at the point where one bridge was broken. The water, seeping in through the crack, not only chilled the cylinder but also flooded the exhaust. No welding outfit was anywhere near the jungle and it was up to us to get the engine repaired. With a kill or cure attitude we drilled and tapped a series of small holes along the break. These were filled with threaded plugs made from steel rods taken out of some old arc lamps. To prevent the rings from catching all were doweled and the exhaust ports chamfered at each end. The engine was again placed in service and ran as well as ever. The worst feature of all these repairs was the necessity to hurry, since one night was as long as we dared stay out of lights. To keep the plant running called for hard, heart-breaking work every day; quite different from being in charge of a modern plant close to civilization where repairs can be secured at an hour's notice.

Finally, one Friday night, just to show she was not entirely conquered, the engine broke the hot bulb, or combustion chamber. This was shaped somewhat as in Fig. 5. The damage was evidently due to the carelessness of the engineer. From what I could determine by

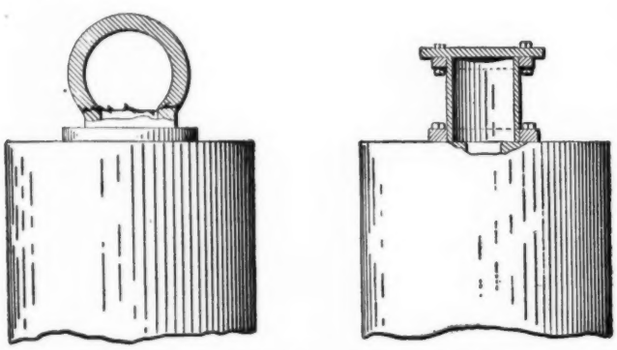


FIG. 5. EMERGENCY HOT BULB

examination and by Jim's usual habit of sleeping, the load had increased, causing the bulb to grow red hot and, with no water injection to cool it, the engine had preignited violently. The bulb was the weakest point and gave way. Of course no extra bulbs were on hand, so we were up against it for fair. It was impossible to have one cast for the reason that no foundry existed within a hundred miles or so. Since we were compelled to have the engine running by Sunday night it was necessary to get busy. The only solution that I could see was possible was to build a makeshift hot bulb. Hunting among the scrap, I found two 4-in. extra heavy pipe flanges and a 4-in. nipple. To find out the size of bulb necessary I took the two pieces of the old bulb and filled them with water. Measuring the amount the two pieces held gave us the volume necessary in the new bulb. The 4-in. nipple was a trifle long and the excess was removed with a hack saw and a few more threads were cut on the lathe. A companion flange to serve as

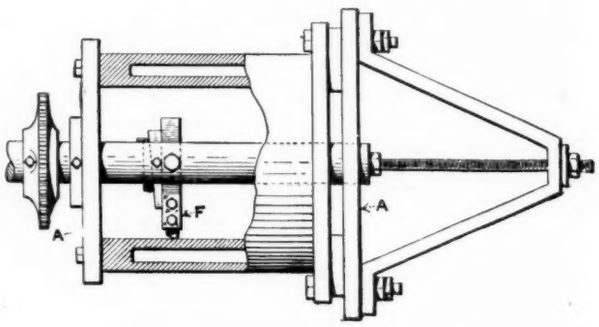


FIG. 6. HOME-MADE BORING BAR

the end of the bulb was made from a piece of cast iron picked out of the scrap pile.

This was all fixed Saturday and before dark the starting torch was placed under the pipe bulb and the engine started. I was considerably worried over our attachment but it worked in a way. The engine had a tendency to race and the bulb got too hot. After much experimenting it was discovered that a small stream of water dripping over the nipple would keep the temperature down to normal. Since Jim's sleeping bench was close to the cylinder head the shower of hot water drops was also useful in keeping him off the bench.

One day a week or so later the Mayor of the town, a fine courtly gentleman, dropped in to see me with the information that, while the house lights were quite satisfactory, since they were lighted at least half the time, the Ayuntamento, or town council, had decreed that the street lights must also be lighted. The big engine, in its present condition, couldn't pull any more load—that was certain. Requesting a few days grace, which was granted, we set to work devising a way to carry this extra load. The small vertical engine had lain down some time before and refused to do much more than run the 3-ton ice machine. Upon examination I found the cylinders badly scored, at least $\frac{1}{4}$ in. clearance between the piston and cylinder walls. Fortunately, over-size pistons had been ordered a year or two previously, but to use them the cylinders had to be rebored. While many engineers have made boring bars, still the problem is somewhat different in a plant having no equipment to use nor any supply house to furnish the necessary parts. Scouting around the town I picked up a piece of 3-in. shafting, originally on some boat, doubtless. With this as a basis for the boring bar a series of holes was drilled in the shaft and shaped into a slot by means of a chisel and file.

The picker on the engine's fuel pump plunger was found to be of tool steel, and one was shaped into a cutting edge and bolted to a bar, *F*, Fig. 6, which became the cutting arm. Two steel bars *A*, *A*, were drilled and used to hold the boring bar in the cylinder. No lead screw could be made, so a modification was adopted. The end of the boring bar shaft was drilled and tapped. A bolt was secured by a washer and nut. Tightening on

the nut held the cutting edge against the work. To drive the bar we rigged up the sprocket wheels and chain shown in Fig. 7. The job had to be done very carefully and, with our crude equipment, it was impossible to drive the bar by engine power. Since labor was only 60 cents per day a cart wheel was placed on one shaft as shown and a native pulling at the wheel turned

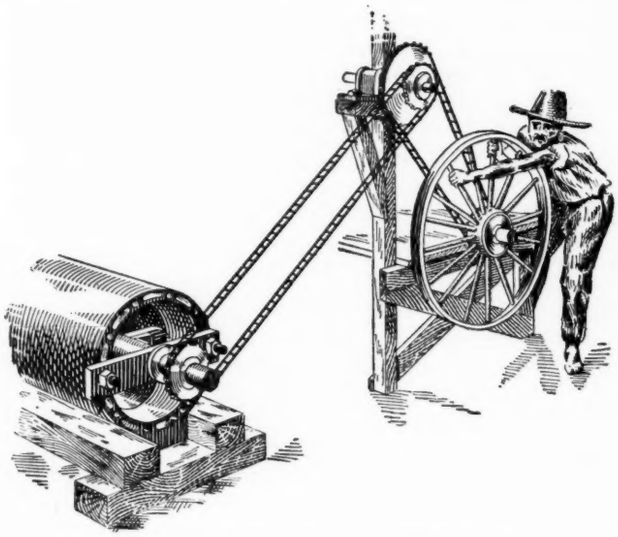


FIG. 7. BORING ENGINE CYLINDER

the bar. It wasn't an easy job, taking days to do it. nor would the cylinder surface pass inspection in the States. But it was fairly round and the piston fitted in a fashion. The important thing was that when the engine was put together it ran well enough to carry the street lights and the town began to look like Broadway.

Largest European Waterwheels

On the Glomfjord in Norway, 20 miles north of the Atlantic Circle, there has been in operation for about one year a hydro-electric power plant of, at present, 77,500 hp., of which is claimed the distinction of using the largest turbine units in Europe; namely, two of 25,000 hp.,and one of 27,500 hp., both machines operating under a head of 1,450 ft. There is room for one more unit ot the latter capacity in the plant. The electric energy is transmitted about three miles to be used for metallurgical purposes. The July 2nd, 1921, issue of the *Zeitschrift Des Vereines Deutscher Ingenieure* (Berlin) contains a detailed description of the hydraulic equipment of this power station. There will be three steel pipe lines having a tapering diameter of 79 to 55 in., two being installed at the present time.

The turbines are of the Pelton type, and operate at 300 r.p.m. Each unit has two runners with 22 buckets, arranged side by side on one side of the generator. The diameter of the runners is 11 ft. and the diameter of the water jet 10 in. A solid flange coupling is used to connect the waterwheel shaft to the generator shaft. The turbine shaft is over 20 ft. long, with only one outside bearing on the wheel, and two generator bearings.

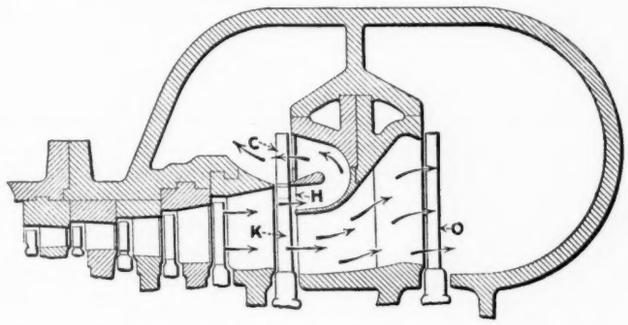
Of special interest is the double acting regulator of the turbines. As is customary on Pelton type wheels, a needle within the nozzle regulates the volume of the water jet in accordance with the momentary load of the machine. This gives an accurate and economic but somewhat slow-acting regulation, which would not take care of a sudden and large change in the load. For this latter purpose a deflector of the water jets is provided. Should the load on the generator drop a large amount suddenly, the jet deflector will act immediately. While the deflector is acting the needles within the jets are slowly advanced to their proper position, and as they advance the deflector is swung back again. The regulator is driven by a belt from the main shaft. Should the belt break or slip off, a small auxiliary Pelton wheel is automatically started up, and maintains the drive of the regulator. Another novel feature is the use of a hydraulic brake to stop the turbine quickly. It consists of a small jet of water, 1.5 in. dia., which can be directed against the backs of the buckets.

During the official tests after installation the 27,500-hp. turbine showed an efficiency of 88.2 per cent. A sudden decrease of the load from 27,500 hp. to 4,500 hp. resulted in an increase of speed of only 8.8 per cent.

Improvement in Steam Turbines

One of the problems confronting the designer of large turbines is that of blading length, which in the last stage may become excessive. These long blades are subjected to severe vibrational stresses, and damage to the last stage is a potential, if not an actual, danger in large machines.

With a view to reducing the length of the last-stage blades, which depend on the volume of the steam passing through the wheel, the design shown in the illustration has been brought out in England. Here the steam from the stage *K* is divided into two streams, one of which passes through the final stage *O*, while the second stream is diverted by the passage *H* back into



LOW-PRESSURE STAGE BLADING

blades *C*, which are an extension of the blades of stage *K*. In this way the length of the blades on wheel *O* is much less than is possible without the division of the steam into two parts.

The heater is a very important part of a fuel-burning installation. It is essential that the heater not only have sufficient capacity to handle the oil being used at the time, but that it be able to raise the maximum volume of oil that might be required to the highest temperature that might be made necessary by the use of a highly viscous oil.

Bituminous coal production in the week ended Sept. 24 totalled 8,506,000 tons, the largest week's output since January.

Power-Plant Accounts—VI. How to Record the Indirect Expenses

By WILFRED A. MILLER

IN THE preceding discussion we went into the detail of the Indirect-Expense elements of power cost, and in particular we developed the methods by means of which we could arrive at the correct charges to make for taxes. We found, first, that we may not know the exact amount of the taxes for the year until we are well along in it, and that after we do know what they are we have to split them up and assign its proper share of them to the power plant. If the amount is not known at the beginning of the year, we cannot wait until we find out what it is, because we must include as nearly the correct amount as possible in the expense for each month. We must therefore make a good guess of the amount, in which we will be aided very materially by the taxes paid in preceding years.

Let us suppose that we have made such a guess fo a year and have divided it by twelve to get the expense per month. Hav ing done so, we enter the amount in the journal in the manner indicated in the upper part of Fig. 1. From this entry it will be recognized that we are going to keep only one account in the ledger for all the indirect expenses. That is, we are not going to have a separate account for each kind of indirect expense. This is at variance with what we did in the case of the direct expenses, because there, it will be remembered, we started a ledger account for each kind of expense, as Labor, Fuel, and so on. The reason that we do not do the same thing with the indirect expenses is that there are fewer of them and each one generally requires only one entry every month. It is, therefore, not a difficult matter to pick out the different items of one kind from the Indirect-Expense account if ever we want to do so. As a matter of fact there will not be much occasion for doing it.

> This is the sixth of a series of articles written in conversational style and treating the subject of power-plant accounts in a thorough, yet simple manner. They were prepared primarily for the guidance of the operating engineer who wants to keep track of the cost of the power he is making, but who knows nothing at all about bookkeeping. Others may find these articles helpful in clearing up their ideas on the subject. This installment starts by reviewing part of what has gone before and then explains how to enter in the journal and post to the ledger, the various items of Indirect Expense. Particular attention is given to the question of taxes.

The indirect expenses differ from the direct expenses in the respect that we have no control over them, whereas we have a very decided control over the direct expenses. Thus, no matter how we may twist and turn to cut down the cost of power, we can in no way influence the amount of taxes we must pay nor any other of the indirect expenses. They are fixed and beyond our control. But this is not true of the direct expenses. These are very much under our control. For example, we may be able to reduce the coal consumption in one of several different ways, such as finding and stopping furnace-wall leaks, insisting on better firing, feeding the boilers more regularly, using a different grade of coal, rebuilding the boiler furnaces, and many others that will occur to all of us. Or we can be on the lookout for steam leaks, poor vacuum and the like. We may be able to make a saving in wages by installing labor-saving devices, such as conveyors, hoists, etc. In fact, we have absolute control of the direct expenses because they are the ones that are affected by our operation of the plant. They demand constant vigilance on our part to keep them as small as possible; were we to relax it in any way, the costs would soon begin to mount up.

From the foregoing it will be obvious that it is much more important to have a comprehensive analysis of our direct expenses than of our indirect ones. That is, we should be able to go to our ledger and pick out each item of direct expense without any fuss, which means that we must have a separate account in the ledger for each one. Then we shall be able to compare the various items of one month with those of another, and by means of a careful study of such information we can learn where efficiency is slacking off or where a change in operation is justifying itself; in fact, we can keep our finger right on the pulse of the plant as we could do in no other way. This, really, should be the prime object in starting a set of books; namely, to provide ourselves with a reliable record from which we can study the conditions in the plant, to find out where we are doing well and where we are doing poorly; how we can improve and operate more efficiently; whether what we consider improvements are really such or whether our records prove to us that we are merely fooling ourselves. That is the greatest object to be sought in keeping costs. Merely to be able to go to the management and say, for example, "Here, I know now that I am generating current for 1½c. per kilowatt-hour," does not get us very far. It is of course well to know it, but it does not help to cheapen the cost of manufacturing. It is past and gone, and if the cost had been 5½c. instead of 1½c., the firm would have had to pay it just the same; in fact, they had already paid it.

On the other hand, if we can go to the superintendent and say, "Mr. Jones, it cost us 1½c. per kilowatt-hour to generate power last month, but from my books I think I see where I can cut that down to about 1⅓c. next month," and if in addition to that we can come back at the end of the next month and say "Well, we managed to do even a little better than I figured; we cut it down to 1¼c. per kilowatt-hour," we have accomplished something to be proud of and we have used our bookkeeping for something far more important than just "finding cost"; we have used it to cut down our cost, thus helping the factory to cut down its cost and enabling it to meet competition that much better. Incidentally, we shall have contributed

our mite to that increasingly important factor in our economic life, conservation. Hence, let us always bear in mind that our bookkeeping is not only for the purpose of finding cost, but also for the purpose of furnishing us with operating data.

We now see why it is so important to keep an individual record of each direct expense, and why this

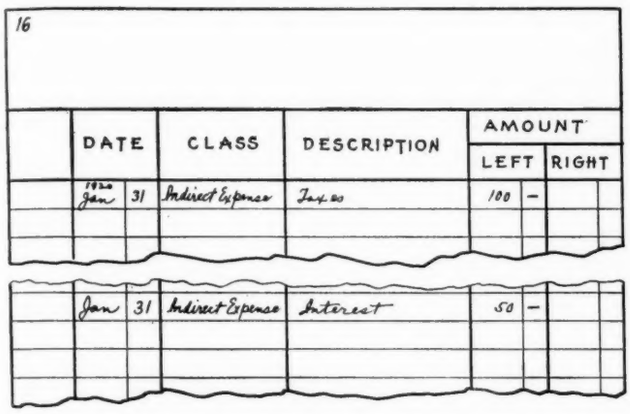


FIG. 1. INDIRECT-EXPENSE ENTRIES IN THE JOURNAL FOR JANUARY

is not true of the indirect ones. Having settled this point, we are ready to go ahead with the discussion of the indirect expenses. Again directing our attention to the item of Taxes, we find that we have reached the stage where we made a monthly entry such as indicated in the upper part of Fig. 1. As the months roll by, we shall have to make a similar entry for each of them. Suppose that our tax bill is not ready until some time in December; then we shall have made a series of journal entries as shown in Fig. 2, so that for eleven months we would have entered taxes as being $100 per month, or 11 × 100 = $1,100 for the eleven months.

Assume, now, that the tax bill when finally available says that the total taxes are so much that when we have figured out the power plant's share it comes out to $1,300 for the year. What are we going to do about it? If we entered $100 for December, as for the other months, the total for the year would be only 1,100 + 100 = $1,200, whereas the tax collector wants $1,300 from us. The only thing to do under the circumstances is to say that our taxes for December are $200 instead of $100 and let it go at that. We made as good a guess as we could; more we cannot do. What it all means is that the costs we got for January to November are somewhat too low and that for December somewhat too high. This should not discourage us at all. We know that taxes are only a small part of our expense and the difference that our unavoidable error will make in the cost of a pound of steam or of a kilowatt-hour will be so small that we would have to go looking for it with a microscope to find it.

To come back to our books then, the December entry would be as shown in Fig. 3. Assume now that all the journal entries for the year have been properly posted to the ledger. Also, for the sake of simplicity, let us assume that the only indirect expense for the year was that for Taxes. Then the ledger account for Indirect Expenses would look like Fig. 4, which shows us that we have entered $1,300 worth of taxes, as we should.

To present a case opposite to the one just discussed, let us assume that we have, owing to an unforeseen drop in the tax rate, overestimated the amount of the yearly taxes instead of underestimating them as in the other case, and that as a matter of fact our share of the taxes amounts to only $1,000 for the year. What shall we do then? We have entered 11 × 100 = $1,100 for taxes, so that we already have too much on the books. If the taxes had been, say, $1,125 or even $1,100, we could have gotten around it by entering only $25 for December in the one case or nothing at all in the second. But we can use neither of these expedients if the amount is less than $1,100, as it is assumed to be. Under these conditions we will discover the usefulness of the right and left columns in the journal and ledger. The state of affairs is that we have already entered $1,100 against taxes, whereas the total for the year is only going to be $1,000. That means that we must

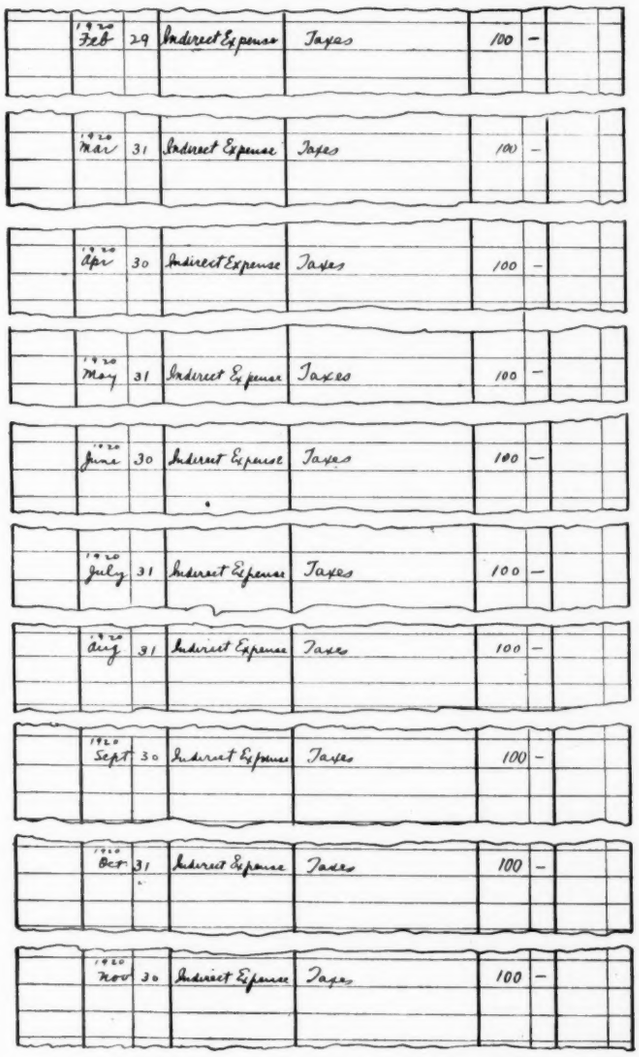

1920 Feb 29 Indirect Expense Taxes 100 –
Mar 31 Indirect Expense Taxes 100 –
Apr 30 Indirect Expense Taxes 100 –
May 31 Indirect Expense Taxes 100 –
June 30 Indirect Expense Taxes 100 –
July 31 Indirect Expense Taxes 100 –
Aug 31 Indirect Expense Taxes 100 –
Sept 30 Indirect Expense Taxes 100 –
Oct 31 Indirect Expense Taxes 100 –
Nov 30 Indirect Expense Taxes 100 –

FIG. 2. MONTHLY JOURNAL ENTRIES FOR TAXES FROM FEBRUARY TO NOVEMBER (INCLUSIVE) MADE ON THE ESTIMATE THAT THE YEARLY TAX BILL WILL BE $1 200

reduce the Indirect Expense account by the difference; namely, $1,100 — $1,000 = $100.

To do this we make an entry in the journal for December in the same manner as for the other months, but we enter the amount in the right-hand instead of the left-hand column. Then, when we come to post this entry we do so to the right-hand side of the account in the ledger. We now find that the journal entry for

December is like Fig. 5 instead of like Fig. 3, and the ledger account for Indirect Expenses is like Fig. 6 instead of Fig. 4. From Fig. 6 we see that the amount of taxes for the year comes out correctly as $1,000. Of course it must be understood that in practice other postings besides those for taxes would appear on the ledger

	1920 Dec	31	Indirect Expenses	Taxes	200	–		

FIG. 3. TAX ENTRY IN JOURNAL FOR DECEMBER TO FINISH OUT FIG. 2 ON THE BASIS OF AN ACTUAL YEARLY TAX BILL OF $1,300

INDIRECT EXPENSES

DATE		EXPLANATION	REF.	AMOUNT		DATE		EXPLANATION	REF.	AMOUNT	
1920 Jan	31	Taxes	16	100	–						
Feb	29	Taxes	20	100	–						
Mar	31	Taxes	24	100	–						
Apr	30	Taxes	27	100	–						
May	31	Taxes	31	100	–						
June	30	Taxes	36	100	–						
July	31	Taxes	40	100	–						
Aug	31	Taxes	44	100	–						
Sept	30	Taxes	49	100	–						
Oct	31	Taxes	54	100	–						
Nov	30	Taxes	58	100	–						
Dec	31	Taxes	63	200	–						
				1300							

FIG. 4. LEDGER ACCOUNT COVERING INDIRECT EXPENSES (TAXES ONLY) ON THE BASIS OF AN ASSUMED YEARLY TAX BILL OF $1,200 AND AN ACTUAL BILL OF $1,300

page for Indirect Expenses, but no matter how many there may be, we can always get the net amount of the account by subtracting the right-hand total from the left-hand one. As explained on a previous occasion, and as indicated in Figs. 4 and 6, the total, to date, of each column may be entered in small figures at the foot of the column, and the difference between the totals of the left-hand and right-hand columns be entered in small figures in the explanation column on the side of the account which is the larger of the two.

We have now come to the point where we have disposed of two of the elements of indirect cost, namely Depreciation and Taxes. The former was discussed at some length in a previous article, and we have just finished consideration of the latter. It will be remembered that the list of indirect expenses, as we have laid it out, consists of: (1) Depreciation; (2) taxes; (3) interest; (4) insurance; (5) obsolesence; (6) general charges. From this we see that the next element to claim our attention is Interest. In general we will not have to do much guessing about the amount of interest to be charged, as we have seen we must sometimes do in the case of taxes. The same holds true of the other indirect elements of cost in our list. We may have to do some figuring to determine how much to enter for them, but we can do that whenever we are ready to start our books, and it is therefore not a case of waiting for someone on the outside to notify us of the amount. Having determined the interest charge against us for the year, we divide it by 12 to get the amount per month and enter that amount regularly each month in a manner similar to that indicated in the lower part of Fig. 1 for January, 1920. Of course these entries are posted to the ledger like all other journal entries. In this case, as for Depreciation and for Taxes, the posting is made to the Indirect Expenses account, in the "Explanation" column of which we enter the notation "Interest."

The next item in line is Obsolesence. As explained on a former occasion, we seldom run into this particular kind of expense in the plant of moderate size, but where it does crop up it is treated along exactly the same lines as we have just finished discussing for Interest, and it will therefore be unnecessary to describe it again in this case.

The remaining item of our list, General Charges, does not require much discussion. Indirect expenses that we cannot include under any other of the headings are entered under this caption. They are pretty well defined in character and are entered as they occur.

	1920 Dec	31	Indirect Expenses	Taxes			100	–

FIG. 5. THE SAME AS FIG. 3 EXCEPT THAT ACTUAL YEARLY TAX BILL IS $1,000 INSTEAD OF $1,300

INDIRECT EXPENSES

DATE		EXPLANATION	REF.	AMOUNT		DATE		EXPLANATION	REF.	AMOUNT	
1920 Jan	31	Taxes	16	100	–	1920 Dec	31	Taxes	60	100	–
Feb	29	Taxes	20	100	–						
Mar	31	Taxes	24	100	–						
Apr	30	Taxes	27	100	–						
May	31	Taxes	31	100	–						
June	30	Taxes	36	100	–						
July	31	Taxes	40	100	–						
Aug	31	Taxes	44	100	–						
Sept	30	Taxes	49	100	–						
Oct	31	Taxes	54	100	–						
Nov	30	Taxes	58	100	–						
				1100							

FIG. 6. THE SAME AS FIG. 4 EXCEPT THAT ACTUAL TAX BILL FOR THE YEAR IS $1,000 INSTEAD OF $1,300

Thus, a combustion engineer may have been called into consultation regarding our fuel and the manner of firing it. When his bill for services rendered comes in, we must enter it in the journal. When we come to pick the account to which it should be charged we find that there are only two that we can consider, one of which is "Miscellaneous" of the Direct Expenses and

the other "General Charges" of the Indirect Expenses. We can certainly not call such a service a direct expense of generating power, hence, we find that it must be placed under General Charges of the indirect list. Whatever the entries for general charges may be, they are entered and posted in the same way as are all other expenses.

Having completed our list of indirect expenses, let ue take a brief survey of the ledger. As it now stands it contains a separate account for each direct expense, a single account for all the indirect ones, and in addition to that a single account for investments. There is also an account for Total Cost. In an earlier article it was explained that we entered in this last account the total of each of the direct-expense accounts, being careful, however, to exclude the Investment account. Having now established our indirect expenses account, we must also enter its total each month in the Total Cost account. The final result is that we have provided a complete record, month by month and total to date, of each element of expense and of the grand total of them all taken together, and we are therefore in a position to make whatever analyses we choose of the cost of power generation.

Why the Absorption System Failed

BY M. C. JACKSON

Some years ago, while in a small town installing part of the equipment of an ice plant, I was called on by the chief of the largest hotel in town to see if his refrigerating plant, which for some reason refused to do the work it had done before, could be put into shape.

Attention was first given to the refrigerating machine, which was of the absorption type, and after going over the whole thing two or three times I was unable to find anything wrong. Checking up on the work done by the plant it seemed that the plant was amply large, and I began to imagine that there must be something wrong with the brine cooler. However, this did not seem possible because the brine temperature and that corresponding to the back pressure on the machine showed a difference of only about 8 deg., which is excellent work.

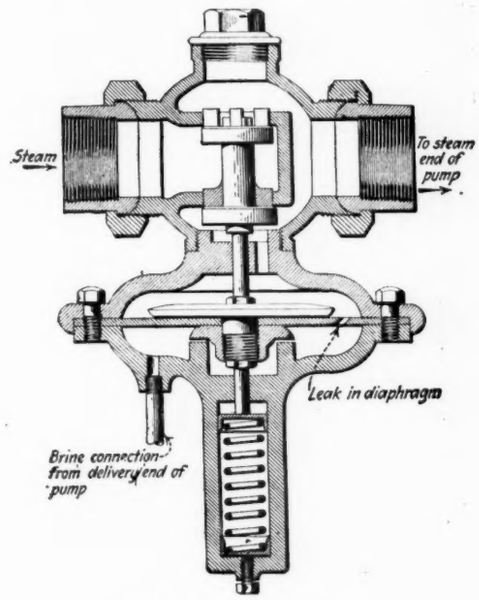
For some reason the brine temperature refused to stay down where it ought to be and the amount and temperature range of the condensing water showed plainly that the machine was doing more than its rated capacity. After spending the better part of half a day on the job, an automatic regulator of the brine pump, which maintained a brine pressure of 70 pounds on the brine system, attracted my attention. The regulator, the engineer stated had not been working properly for some time and they had to regulate the pressure by the throttle valve to the pump.

By placing my hand on the discharge line from the pump I was surprised to find that there was apparently a considerable difference in temperature below the point where the pressure connection from the brine line to the pressure regulator was taken, as compared with the temperature above this point.

This started another investigation and it was found that, while the regulator was apparently not doing any good, the steam connection to it was wide open. After shutting this off and removing the regulator we found that the diaphragm had a large hole in it, as shown in Fig. 1, and live steam at 100 lb. pressure had been blowing straight through it and through the pressure connection to the brine line, directly into the brine as it passed to the system. In many cases the steam pressure had dropped down to 60 pounds and the process had been reversed, with the brine going into the steam line and back into the pump. Considerable trouble had been encountered with groaning of this pump and this was now easily explained. After the diaphragm was repaired no more trouble was experienced and there was no trouble in maintaining the required capacity.

In another case I was called in to find out why an absorption plant that we had recently installed lost such large quantities of ammonia. The man in charge blamed it on the system, claiming that it ruined the ammonia.

I spent the greater part of a day around the plant while the engineer, openly hostile because he had wanted a compression plant in the first place, refused to offer



LEAKY PUMP REGULATOR

any information except that the machine was no good and that it would ruin the company keeping it supplied with ammonia.

While looking around the machine my attention was attracted by a connection to the outlet from the safety valve on the generator. Tracing this to its end I found that it ended up in a spray pond outside of the plant. The end was below the water level and by inserting a piece of scantling under it we were able to raise it out of the water, whereupon the air was filled with a healthy smell of ammonia.

Going back into the engine room we dismantled the connection to the safety valve and were almost choked with the ammonia fumes. From all appearances the pressure had risen to such a point that the safety valve had operated and it had stuck before it closed properly. Ever since that time the ammonia had leaked out through it and through the connection to the spray pond that the engineer had rigged up. After the valve had been reground no further complaint was made about the loss of ammonia. Also, the connection from the valve to the spray pond was disconnected and left out, as it is better to have a little smell in the engine room once in a while than to have a connection where it is impossible to tell when the ammonia may be leaking through.

Draft Tubes—How They Operate and Why

An Elementary, Non-Mathematical Explanation of Hydraulic Draft Tubes—Use of The Barometer and The "Scenic Railway" To Illustrate The Fundamental Principles Involved

THIS article will explain in the simplest manner possible what a draft tube is and how it works. A draft tube is a tube of any shape conducting the water from a hydraulic turbine to the tailrace. An essential requirement of any draft tube used with a turbine above the tail-water level is that it be air-tight and have an airtight connection to the turbine discharge, for such a draft tube does more than carry the water away from the turbine; it produces a "draft" or suction on the discharge side of the turbine, and any air leakage into the tube tends to break this suction. Another very important function of a properly designed draft tube is to make use of the velocity in the water discharged from the turbine. There are several varieties of draft tubes, but before describing any of them it will be well to consider the fundamental general facts, or "laws of nature," upon which they depend for their action.

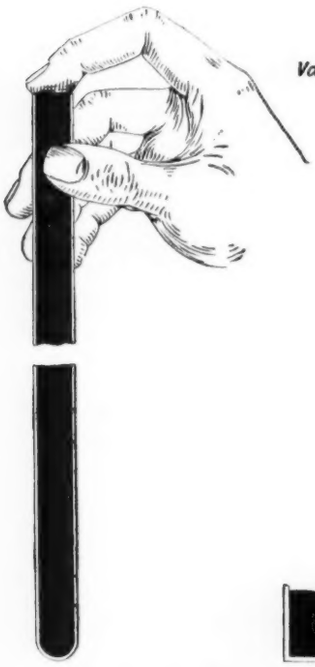


FIG. 1. FIRST STEP IN MAKING A BAROMETER

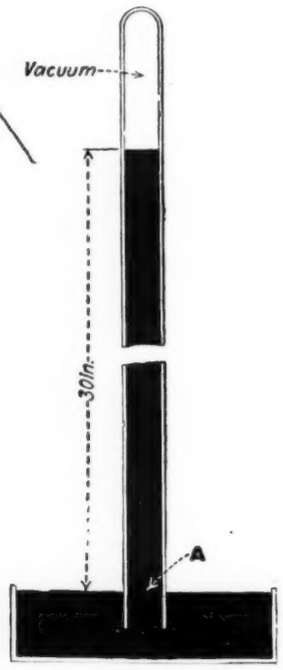
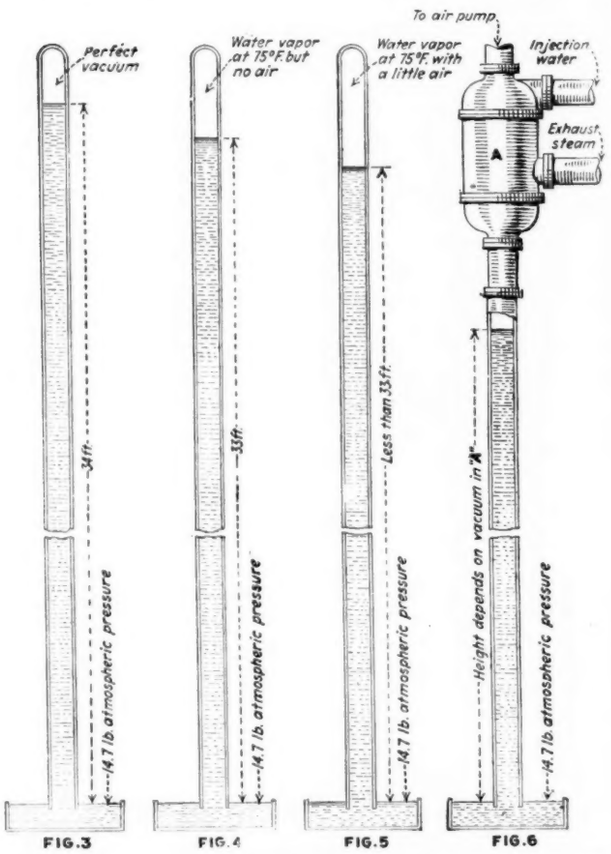


FIG. 2. MERCURY BAROMETER COMPLETED

The use of the draft tube depends on the fact that the earth's atmosphere has weight. If a square, one inch on a side, is laid out on the ground at sea level, the total weight of the air straight above it varies slightly from day to day, but averages 14.7 lb. For the purpose of this discussion it will be assumed that it is always 14.7 lb. The imaginary column of air above this square is many miles high and yet weighs only 14.7 lb. because air does not weigh much even at the earth, and gets rarer the higher one goes. On the other hand, columns one inch square of heavy and practically incompressible fluids, such as water or mercury, need a height small in comparison to weigh 14.7 lb. The figure for water is 34 ft. and for mercury is 30 in. (both of these figures being close approximations, quite sufficient for most practical purposes).

To sum up, three columns, each one inch square, the first of air and as high as the earth's atmosphere, the second of water and 34 ft. high, the third of mercury and 30 in. high, will each weigh 14.7 lb. In each case the weight of 14.7 lb. is entirely carried on the base one inch square. It is then evident that the pressure on the base is 14.7 lb. per sq.in. If the cross-sectional area of the column were greater, say three square inches, the weight resting on the base would be $3 \times 14.7 = 44.1$ lb., but the pressure *per square inch* would be $44.1 \div 3 = 14.7$ lb., exactly the same as before.

Now suppose a piece of paper one inch square is held horizontally near the surface of the earth. The pressure on the top surface is 14.7 lb. The reason the piece does not seem heavy is because the air also presses upward on the bottom with a force of 14.7 lb. In fact, it can be proved by both theory and experiment that the pressure in pounds per square inch at a given point

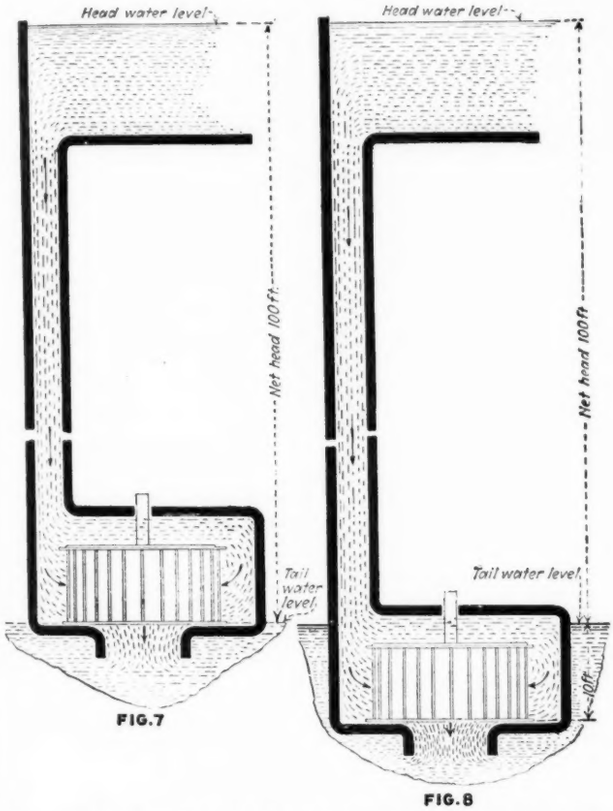


FIGS. 3 TO 6. BAROMETRIC WATER COLUMNS UNDER VARIOUS CONDITIONS

Fig. 3—Water barometer with perfect vacuum above the column. Fig. 4—Water barometer with vapor above the column. Fig. 5—Water barometer with vapor and some air above the column. Fig. 6—Barometric condenser.

in any fluid is the same in all directions, down, up, horizontally or at any angle. The pressure in pounds per square inch is always equal to the weight of a column of the fluid one inch square, having a height equal to the depth (beneath the free surface of the fluid) at which the pressure is measured.[1]

The barometer is based on this principle, and it will pay to spend a few minutes in discussing it. A barometer can be made as follows: A glass tube, somewhat more than 30 in. long and sealed at one end, is held with



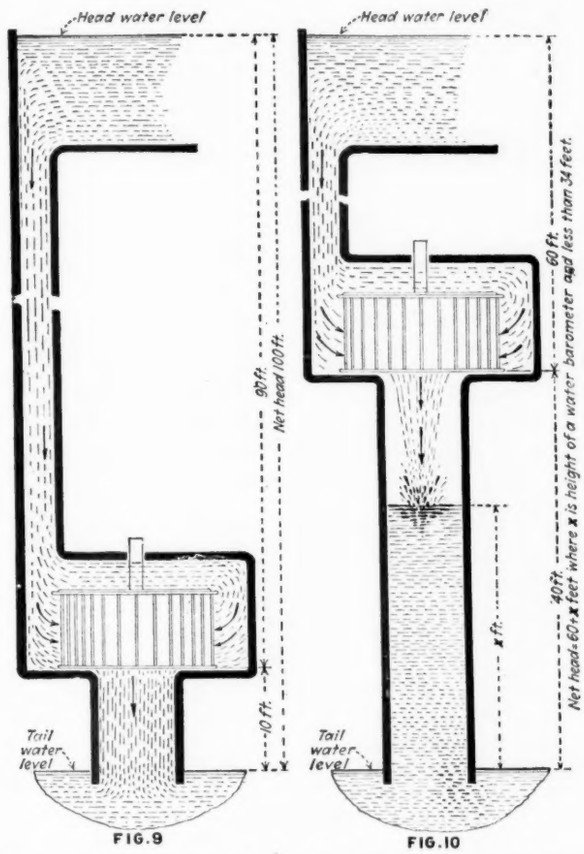
FIGS. 7 AND 8. DIAGRAMS OF TURBINE INSTALLATIONS WITH LOW WATER VELOCITIES

Fig. 7—Turbine with discharge at tail-water level. Fig. 8—Turbine with discharge 10 ft. below tail-water level.

the sealed end down, then it is completely filled with mercury and closed with the finger, as shown in Fig. 1. It is next inverted and the end stopped with the finger is dipped into a bowl of mercury. When the finger is removed, the mercury will fall a little but remain approximately 30 in. above the surface of the mercury in the dish, as shown in Fig. 2, the exact height depending on the atmospheric weight (or pressure) at the particular time and place. If the atmospheric pressure is 14.7 lb. per sq.in., the height will be almost exactly 30 in. This is easy to explain. At the point *A* (level with the mercury in the dish) the atmosphere is producing an upward push of 14.7 lb. per sq.in., which, as just stated, is enough to balance the weight of a 30-in. column of mercury. It is essential that no air be pocketed in the top of the tube, for then it would add its downward pressure to that of the mercury. If the top were open to the air, the mercury in the tube would fall.

[1]This assumes, of course, that there is a vacuum above the fluid. The absolute pressure one foot below the free surface of water in the open air would be the pressure due to a one-foot column of water *plus* 14.7 lb. per sq.in air pressure.

A similar barometer could be made using water instead of mercury. In this case the tube should be more than 34 ft. long. If it were possible to have a perfect vacuum above the water, the column would rise to a height of 34 ft., as shown in Fig. 3. However, in practice it would be found that the top of the water column would come to rest at a height somewhat less than 34 ft. for an atmospheric pressure of 14.7 lb., because of the fact that vapor from the water would fill the top of the tube and press downward. For instance, if the temperature of the water were 75 deg. F., the absolute pressure of the vapor would be 0.43 lb., which would force the column down about one foot, as shown in Fig. 4. A higher temperature would produce a greater vapor pressure and force it down still more. Moreover, if any of the dissolved air usually found in water were released, this would still further increase the pressure above the water and thus lower the column, as indicated in Fig. 5. So, if the exact effect of vapor and air bubbles is not known, it can only



FIGS AND 10. DIAGRAMS OF TURBINE INSTALLATIONS WITH LOW WATER VELOCITIES

Fig. 9—Turbine with discharge 10 ft. above tail-water level Fig. 10—Turbine with discharge 40 ft. above tail-water level.

be said that the water will rise to a point somewhat less than 34 ft.

At this point it might be well to point out the differences between absolute pressure, gage pressure, and suction, or negative pressure. It is often customary, for the sake of simplicity, to speak of atmospheric pressure as zero. The ordinary steam gage is set to read zero at atmospheric pressure, so the absolute or true pressure is 14.7 lb. more than the gage reads. Where the absolute pressure is less than 14.7 lb. the

difference between it and 14.7 lb. is frequently called "suction" or "negative pressure." For example, a suction of 3 lb. per sq.in. really means that the absolute pressure is 14.7 — 3 = 11.7 lb. per square inch.

It is evident that pressure can be expressed in pounds per square inch, in inches of mercury or in feet of water. The relation is this: 14.7 lb. per sq.in. = 30 in. of mercury = 34 ft. of water. To turn one into the

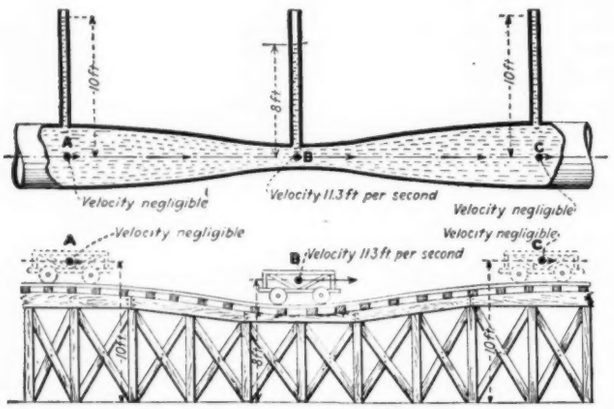


FIG. 11. ANALOGY ILLUSTRATING RELATION BETWEEN VELOCITY AND "HEAD"

other, use the following relations, which will be seen to check the foregoing with reasonable accuracy:

Pounds per square inch = inches of mercury ÷ 2.04.

Inches of mercury = pounds per square inch × 2.04 (for rough work use 2 instead of 2.04).

Pounds per square inch = feet of water ÷ 2.3.

Feet of water = pounds per square inch × 2.3.

Feet of water = inches of mercury × 1.13.

Inches of mercury = feet of water ÷ 1.13.

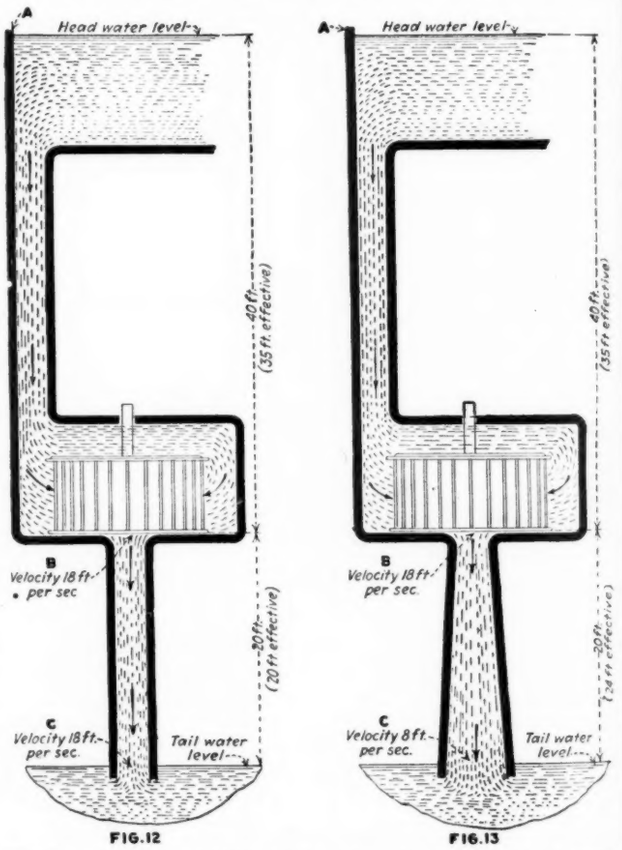
The foregoing preliminary information is more than is really required for an explanation of the draft tube, but the additions have been introduced because they fit in well with the other facts and are generally useful in engineering work.

An interesting application of the principles just discussed is found in the barometric condenser. Such a condenser is shown in Fig. 6. The exhaust steam is condensed by a water spray in the chamber *A*, and the hot water is drawn off without the aid of a pump by the use of a discharge pipe of a height greater than that to which the atmospheric pressure outside could force water against the low pressure of the exhaust steam and entrained air in the head of the condenser.

Now, turning to the hydraulic turbine, Fig. 7 shows a diagrammatic sketch of a central-discharge turbine.[2] The head, measured from the surface of the head water to that of the tail water, is 100 ft. All of our previous discussion has been about water at rest. Comparisons will hold here if the water is moving slowly. Higher velocities will introduce other considerations that will be taken up later, after the simpler case has been fully explained.

Fig. 7 shows the turbine exactly at the level of the tail water. The head, or pressure acting on the turbine, is 100 ft. of water. If there were no losses such as those due to inefficiency of the turbine, skin friction between water and the surfaces it touches, or internal friction due to eddies in the water, each pound of water passing through the turbine would deliver 100 ft.-lb. of work at the turbine shaft, since the work done by a falling body is equal to the weight multiplied by the distance fallen. If 100,000 lb. of water passed every minute, the work delivered at the turbine shaft would be 100,000 × 100 = 10,000,000 ft.-lb. every minute. Since one horsepower is 33,000 ft.-lb. per minute, the turbine would develop 10,000,000 ÷ 33,000 = 303 hp. If the efficiency of the whole installation were 80 per cent, the developed horespower would be 80 per cent of 303, or 242 hp. This is introduced here to show that for a given flow of water the work done every minute, and hence the horsepower, is in direct proportion to the head acting on the turbine (in this case 100 ft.). For 200 ft. head and the same flow and efficiency the power would be twice as much.

What would happen if the turbine were lowered to a point ten feet below the level of the tail water, as shown in Fig. 8? The power would be just the same, for the net head would still be 100 ft. It is true that the head above the turbine would now be 110 ft., but there would



FIGS. 12 AND 13. DIAGRAMS OF TURBINE INSTALLATIONS WITH CONSIDERABLE WATER VELOCITIES

Fig. 12—Turbine with cylindrical draft tube which does not use velocity in the turbine discharge. Fig. 13—Turbine with conical draft tube which gradually slows down the water and thus recovers (in the form of added suction) most of the velocity in the turbine discharge.

be a back pressure, or head of tail water, amounting to 10 ft., leaving a net head of 110 — 10 = 100 ft. as before.

Now suppose that the turbine were raised 10 ft. above the level of the tail water, as shown in Fig. 9, and the discharge carried by an airtight draft tube to a point below the surface of the tail water. The head above

[2]It should be clearly understood that the installations shown in Figs. 7, 8, 9, 10, 12 and 13 are purely diagrammatic. Not attempt has been made to show commercial proportions.

the turbine would be only 90 ft., but the weight of the water in the 10 ft. of draft tube (measured above the level of the tail water) would exert a suction or pull equal to a 10-ft. positive head. So in this case the net head would be 90 + 10 = 100 ft., as before.

If the turbine were 20 ft. above the tail water, the head above it would be 80 ft. and the suction, or negative head below, would be 20 ft., giving the same total of 100 ft. as before. There is, however, a limit

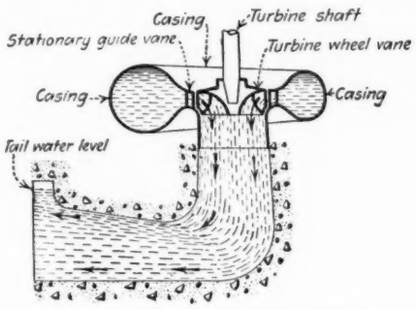


FIG. 14. BENT DRAFT TUBE

to the height that the turbine can be placed above the tail water and still permit the net head to remain 100 ft. Suppose the turbine were placed 40 ft. above the tail water, as shown in Fig. 10. Then the draft tube would only be filled with water to a height of somewhat less than 34 ft. above the tail water. This is true because it is only the pressure of the atmosphere on the tail water that keeps the water up in the draft tube. The principle is the same as with the barometer shown in Fig. 5. Suppose the vapor and air conditions were such that the barometer column rose 27 ft. above the tail water. There would then be a vacuum or suction of 27 ft. of water in the open space above the top of the water column, so that the total net head on the turbine would be 60 + 27 = 87 ft. This would mean that 13 ft. of the available 100 ft. of head would be wasted. It is then evident that the turbine should never be more than a certain height x above the tail-water level, where x is the height of a water barometer under the given conditions and always less than 34 ft.[2] In practice this limiting elevation must be made to refer to the highest point on the blades on the discharge side of the turbine.

The use of the term "suction" in connection with draft tubes may cause some confusion, since it will occur to the reader that when the turbine is, say, 20 ft. above the tail water, the tail water is really *pushing up* on the discharge side of the turbine with a head of 34 — 20 = 14 ft. instead of *pulling down* with a suction of 20 ft. It must be remembered, however, that the air is also pushing down on the top of the head water with a pressure equal to 34 ft. of head. The *helping* air pressure on the head water just balances the *opposing* air pressure on the tail water, so that it is customary to forget about air pressure (except when it comes to considering how long the draft tube may be and still work properly) because the *difference* between two pressures (or heads) is the same whether they are measured on the absolute or on the "gage" basis.

The general conclusion may now be drawn that below a certain upper limit (somewhat less than 34 ft. above the tail water) the full head can be utilized no matter where the turbine is located, because the net head will always be the difference between the level of the head water and that of the tail water.

In the cases previously discussed, the velocity of the water has not been considered. In actual turbine practice and particularly with modern, high-speed wheels, the water leaving the turbine has a considerable velocity. For reasons that will be explained in a moment, if the water still has this velocity when it leaves the draft tube, it has the effect of making the actual head utilized less than the difference of level between the head water and the tail water. By proper modifications in the draft tube most of this lost head can be recovered in the form of additional suction head.

To make this clear it is necessary to understand how pressure can be changed into velocity and velocity into pressure. It takes pressure or head to produce velocity in water, so that, if water under pressure is allowed to move, the pressure must drop a certain amount, even if there is no friction. This is illustrated by the case of the horizontal frictionless pipe shown in the upper half of Fig. 11. This pipe is assumed to be so constructed that water flows from a larger to a smaller diameter and on again to a larger diameter without any eddies. At A the diameter is large and the water flows with negligible velocity. The pipe is constricted at B so that the velocity at that point is 11.3 ft. per sec.. At C the diameter and velocity are the same as at A. It will be found that if the pressure head of water at A is 10 ft., it will be 8 ft. at B and 10 ft. at C. Thus in order to acquire a velocity of 11.3 ft. per sec. the water has to lose 2 ft. of head. However, by giving up

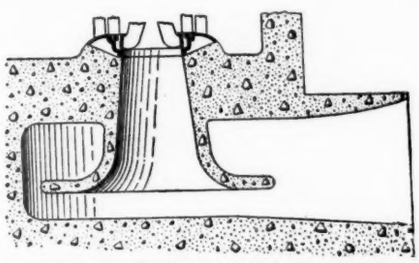


FIG. 15. CROSS-SECTION OF MODEL OF THE WHITE HYDRAUCONE REGAINER

this velocity it is able to regain the lost pressure head.

If a heavy body is allowed to fall freely from rest, it will have the following velocities after falling various distances:

Distance Fallen, Ft.	Velocity Ft. per Sec.
1	8.0
2	11.3
3	13.9
4	16.0
5	18.0

It will be noted that a body falling 2 ft. from rest—that is, losing 2 ft. of "head"—gains a velocity of 11.3 ft. per sec. This is exactly what happened to the water in going from A to B.

In the lower half of Fig. 11 is shown a "scenic railway" with a frictionless car. The car is gently started at A, 10 ft. from the ground, and allowed to roll down to B, where it is only 8 ft. from the ground. The car at B will have a velocity of 11.3 ft. per sec. In each of the three cases (the falling body, flowing water and the rolling car) a velocity of 11.3 ft. per sec. is produced by a 2-ft. reduction in "head." The car will go

[2] In the case under consideration the water velocities are considered to be so small that they can be neglected. If the velocities are appreciable, the limiting height is still further reduced.

on of its own accord and will come to rest at a point *C* where it is once more 10 ft. from the ground. Just as was the case with the water, the 2 ft. of lost head is regained at the expense of the velocity of 11.3 ft. per sec.

This illustrates the general law that for frictionless flow a given fall in head produces a velocity equal to that of a body that has fallen the same distance.

Fig. 12 shows a turbine installation where conditions are supposed to be frictionless as in all the cases previously discussed. This case differs from the previous ones in that the water has a considerable velocity at *B* where it leaves the turbine and enters the draft tube. Let us suppose that this velocity is 18 ft. per sec. Since the water started from *A* with negligible velocity the increase of 18 ft. per sec. must have been accomplished at the expense of 5 ft. of head (from the table) so that, of the 40-ft. drop from *A* to *B*, only 35 ft. is used by the turbine. The draft tube will produce its full suction of 20 ft. since the water leaves it as fast as it

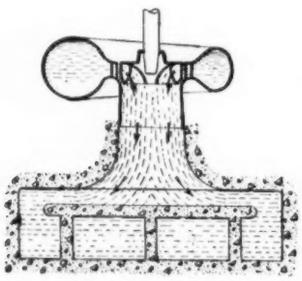


FIG. 16. ANOTHER FORM OF THE WHITE HYDRAUCONE REGAINER

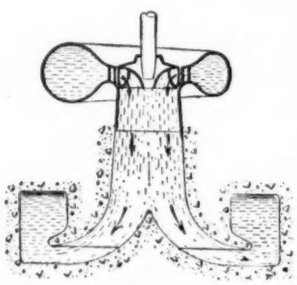


FIG. 17. CROSS-SECTION OF THE MOODY SPREADING DRAFT TUBE

enters (the tube having parallel sides). The total effective head acting on the turbine is then 35 + 20 = 55 ft. out of the 60 ft. difference of level between the head water and the tail water. To put it another way, it might be said that this installation wastes five feet of head because it throws away the water with a velocity of 18 ft. per second.

If the water leaving the turbine were gradually slowed down so that it left the draft tube with a low velocity, the wasted head would be less. This can be accomplished by the use of a conical or expanding draft tube like that shown in Fig. 13. The installation shown is the same as Fig. 12 except that the bottom of the draft tube has an enlarged diameter so that the water leaving it has a velocity of only 8 ft. per sec., which is equivalent to one foot of head.

In this case, as in Fig. 12, 5 ft. of the fall from *A* to *B* is needed to give the turbine discharge its velocity of 18 ft. per sec., so that only 35 ft. can be used by the turbine. The suction produced at *B* by the draft tube will, however, be more than 20 ft. because the water is slowed down while going through the draft tube. The gain will be 4 ft. since the water enters at *B* with a velocity equivalent to 5 ft. of head and leaves *C* with a velocity equivalent to one foot of head. The effective suction at *B* will then be 20 + 4 = 24 ft., and the total effective head on the turbine 35 + 24 = 59 ft. Out of the 60 ft. difference in head between the head water and the tail water, 59 ft. is effective because the velocity in the water discharged from the draft tube is equivalent to only one foot of head.

It may help the reader to form a mental picture of the extra suction produced by the conical draft tube if he will think of an elevator being lowered at constant speed. If the elevator weighs one thousand pounds, the pull in the rope is one thousand pounds. If, however, the elevator is being brought to rest while descending, the tension in the rope is more than one thousand pounds, because the rope must exert a pull to balance the weight plus some more to reduce the speed. The analogy is not perfect because water, unlike the rope, has no tensile strength. However, the atmospheric pressure at the bottom of the draft tube makes the water act "as though" it possessed a tensile strength of almost 14.7 lb. per sq. in.

In practice it is often inconvenient to locate the turbine directly over the tail water as in Fig. 13, and it is usually desired to discharge the water horizontally rather than vertically. For this reason bent draft tubes like that shown in Fig. 14 have been frequently used. Another purpose of the bent draft tube is to gain length. It is evident that in this way it is possible to have a draft tube considerably longer than the difference in level between the turbine discharge and the tail water. This was considered necessary with large turbines because a tube of the type shown in Fig. 13 would have to expand very rapidly to cut the velocity to a low point in a vertical distance of perhaps 20 ft. or less. It was felt that such a sudden expansion in this type of tube would cause wasteful eddies.

There have recently been developed two types of draft tubes that slow down the water without shock in a short vertical distance and remove most of the whirl along with the vertical velocity. One of these, called the White Hydraucone Regainer, is shown in Fig. 15 and also, in slightly different form, in Fig. 16.

In the White tube the water is made to impinge against a large flat plate perpendicular to the axis of the turbine discharge. This causes the water to spread out in all directions. The bell-shaped mouth at the bottom of the vertical portion of the draft tube is so shaped that the area for the flow increases rapidly as the water approaches the edge of the flat plate. This produces a corresponding decrease in the velocity of the water (including the "whirling" velocity) so that most of the discharge velocity is regained in the form of suction head on the wheel.

The Moody Spreading Draft Tube, shown in Fig. 17, is somewhat similar in general appearance to the White Hydraucone Regainer. The most obvious point of difference is that the steam of discharged water does not impinge upon a flat plate but upon a solid cone. Although the flow lines are somewhat different, the general effect is, as before, to spread the water out in all directions through a space of rapidly increasing area with the result that most of the velocity is taken from the water with a minimum loss from shock and eddies. The object of both types of draft tube is to secure efficient conversion of velocity into head with the minimum expense for excavation and construction.

In an elementary article of this type it is not possible to go deeply into the theory of the various types of draft tubes concerning whose relative merits there has been considerable discussion. It should merely be borne in mind that the best any draft tube can do is to produce a suction equal to the vertical distance from the turbine discharge down to the tail water, plus the "head" equivalent of most of the velocity in the turbine discharge. The total effective head acting on the turbine must always be a little less than the difference in level between the head water and the tail water.

Experiences with an Old Time Compressor

By M. C. JACKSON

THERE are still to be found around the country a number of old-style ice machines with vertical double-acting ammonia cylinders, many of them changed over from the original oil-injection design. Fig. 1 illustrates one of these compressors which I encountered in my travels around the country.

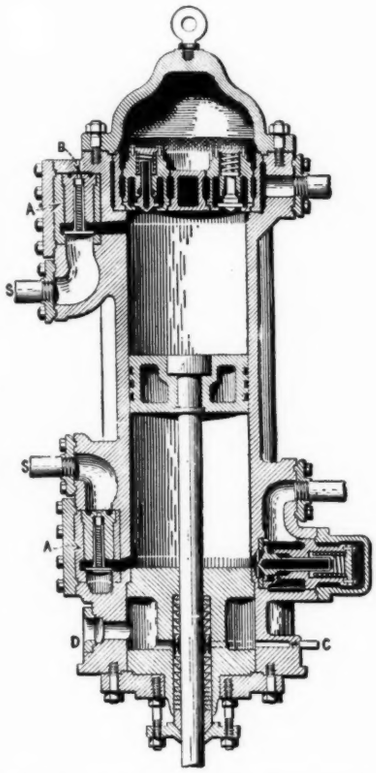


FIG. 1. OLD DESIGN OF VERTICAL DOUBLE-ACTION COMPRESSOR

While this machine did good work when it was in good order, there was always something going wrong with it at the critical moment, particularly if you wanted to speed it up and get a little extra capacity. Some of these experiences may be of interest to the younger operators who yet have to get next to the many problems arising with one of these compressors. The machine was installed in a combination cold-storage and ice-making plant along with two other compressors, which, however, hardly ever made any trouble. The suction gas enters the valve plug *A* from the suction line S, as indicated in Fig. 1, and, passing the valve, enters the cylinder through the slot shown in the side of the valve plug, Figs. 1 and 2. Two pins are placed across the slot, the purpose of which will be evident later.

The valve, which is placed inside a cage *B* had a flat face and seated on a flat surface. From the construction it will be seen that a long spring fits inside of the valve stem, which it will be noted is not very strong at the point where the stem connects to the valve disc. The valves on the machine under discussion had a habit of breaking off at this point, which could generally be detected at once by the jerky action of the machine and by the fact that the frost would come off the particular suction valve that had broken. There was then nothing else to do but to pump it out and put in a new valve.

Some time after I had left the plant, one of the men decided to eliminate this trouble by having the stems made solid and leaving out the spring altogether. The valves made quite a little more racket, but otherwise they seemed to work as well as before, and the stems did not break so often, although it did not entirely eliminate the breaking.

One night there was a terrific thump in the machine, followed by a slight knock in one cylinder every time the crank passed the lower center. The next day the engineers opened up the machine, and although every possible part was examined, nothing was found wrong. Giving up the search, the men replaced all the parts and things went along nicely for a few days, although the piston still had a tendency to knock as it passed the bottom center. It was supposed that this was caused by the clearance being too small, in which case the contraction of the rod when it got cold would cause the piston to touch the bottom head and make the knock.

In an effort to offset this condition the rod was backed out about a turn and then to everyone's surprise the piston began to knock at the top dead center. After juggling it back and forth a number of times, a point was found where the piston would barely knock on the bottom head when it was cold and on the top head when it was hot, indicating that there was practically no clearance. This was quite a puzzle as the machine had been built with $\frac{1}{16}$-in. clearance. However, since the machine worked they let matters rest at that.

The next winter I went back to help with the overhauling. When I inspected the cylinders of the machine,

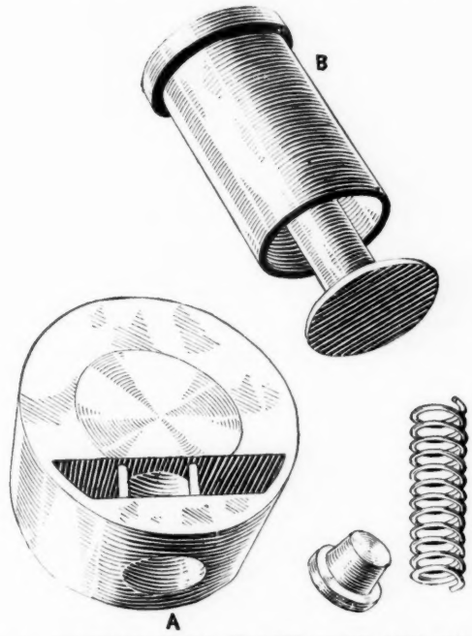


FIG. 2. SUCTION PLUG, VALVE CAGE AND VALVE

I was somewhat puzzled to account for a bright spot on the bottom of this particular cylinder. This led to an inspection of the piston, and my surprise can be imagined when I found a section of one of the broken valve stems driven into the piston, which was of the cored type. The stem was pressed into the piston and extended down below the face of the piston about one-sixteenth inch. This had caused the terrific thump during the summer and also had caused the knock and had practically eliminated the clearance.

The two pins placed across the slot of the suction-valve plug, shown in Fig. 2, had been removed for some

reason, and there was nothing to prevent either the stem or the valve from working its way into the cylinder.

The oiling of the rod also caused us considerable trouble. The construction of the stuffing box is shown in Figs. 1 and 3, the oil entering at *C* and the oil and gas escaping through *D* to the suction line. The recess shown around the stuffing-box gland was for the purpose

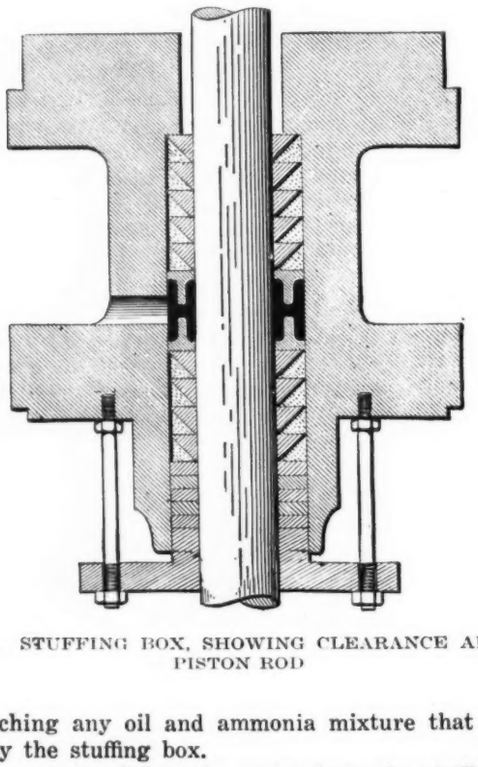


FIG. 3. STUFFING BOX, SHOWING CLEARANCE AROUND PISTON ROD

of catching any oil and ammonia mixture that might leak by the stuffing box.

As a matter of fact the outlet from the stuffing box used to plug up regularly so that it was necessary to pull the old packing with a packing hook. After a few experiences of this kind the engineer drilled a hole two sizes larger where the pipe *C* is shown connected and then drilled another hole the same size as the pipe, through the stuffing box and directly opposite the hole leading to the outlet *D*. The hole into the stuffing box, as well as the enlarged hole at *C*, was now tapped and a half-inch pipe fitted into the hole in the stuffing box and extended out through the hole at *C*, the joint at *C* being sealed with a metallic cement. A common hand oil pump was now connected to the half-inch pipe, and by this means enough pressure could be put on the oil to force it into the stuffing box and also keep the outlet on the opposite side clear. After this we had no further trouble from this cause.

In overhauling the machine at this particular time, the rods were taken out and turned down considerably. When they started up again the next spring, the operators were somewhat puzzled to account for what became of the packing in the rod stuffing boxes of the machine. The machine would run along fairly well for a week or two, and then all of a sudden the rods began to leak, although the packing gland was drawn up tight. One day a slight knock started in one of the compressors and gradually got worse until in the afternoon it gave a sharp ringing sound very much the same if someone was striking it with a hammer. The men looked all over the machine and had every valve out without being able to find anything wrong. Finally, the oiler insisted that it was in the stuffing box of one of the cylinders, and so the machine was shut down again and the packing removed. When they came to pull the oil lantern down, it would not budge with the ordinary screwrods used for this purpose but was finally brought down by turning the machine over. Every bit of packing was gone above the lantern and it had run hot enough to melt the babbitt lining, which had stuck tight on the rod. As usual, there was considerable discussion as to where the packing had gone. The oiler finally called attention to the fact that the hole through the neck of the stuffing box was much larger than the piston rod and suggested that the packing could easily be squeezed out through this space The chief took one look at it and decided that the oiler was right.

To remedy the trouble the usual junk ring, which is always put in the bottom of the stuffing box when the rods are turned down, was made with a snug fit in the stuffing box, and this was placed in the bottom of the stuffing box, or what in this case would really be the top. This ended this trouble.

The Control of Boiler Operation*

WHILE steam boilers are as old as the steam engine or steam turbine, until recent years their possibilities and those of the fuel-burning equipment were overlooked. The use of instruments, particularly of steam-flow meters on individual boilers, awakened engineers to the irregular operations of their boilers and has resulted in many different schemes for improvement. The most important source of loss in the boiler room has been found to be the lack of co-ordination in the operation of the different units. In the modern plant, the steam units operate together almost as one single machine in meeting the variations of the outside load, thanks to an elaborate and completely automatic system of governing the individual units, and it would be a great advantage if the boiler room could be operated on the same principles.

Until the last few years, boiler operation has been comparable to operating a twelve-cylinder internal-combustion engine with a separate non-automatic carburetor for each cylinder, each carburetor being manually controlled by the operater. In case of a change in load, the latter would be compelled to change the throttle opening, air supply and fuel supply to each of the twelve cylinders, and to do this in such a way as to maintain economical proportions. Such is true of boiler operation, where the operators are expected to adjust the air, fuel and draft supply to several boilers in proportion to a load of which they usually have little indication. Over and above their work of looking after the fires, the operators are required to fulfill the functions of a governor. A centralized control system would eliminate most of the uncertainty and loss and leave the operator free to make minor adjustments and to see that everything was operating economically.

Since the load comes onto the entire station, the

*Abstract of paper by Walter N. Flanigan, presented at the Fifth Annual Convention of the Association of Iron and Steel Electrical Engineers, Sept. 19 to 24.

station should advance as a unit to meet it. In other words, the individual boilers must be co-ordinated so as to respond together promptly to changed conditions. With hand control there is a certain lag or inertia before the operator sees the load change on the flow meter and sets his air supply, coal supply, and draft to meet the new conditions. By that time these may have changed again. In any case, the delay has caused a greater pressure drop or rise than should have been occasioned and the result is that the boiler must be

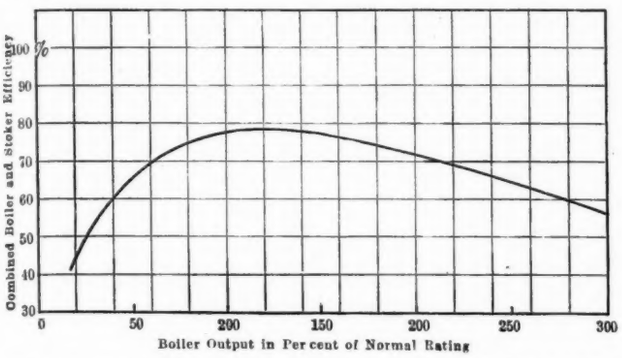


FIG. 1. BOILER EFFICIENCIES AT DIFFERENT LOADS

forced more than enough to carry the changed loads, or shut down to a greater extent than the load change justified, in order to make up for the time lag. As shown by the curve in Fig. 1, every boiler has a certain range over which it has its maximum economy, and the station is usually so designed or the number of boilers on the line so determined as to carry the average load at this range. With the best of hand control, as just shown, the boilers are continually being driven above or below the economical range, even though the average lies well within. This causes an increased fuel consumption. In addition, since the stoker is forced more than necessary at times, and less at other times, the brick work and the boiler and stoker in general suffer and the repairs are high. Moreover, some boilers are usually being pushed to a ruinous rating, while others are lagging, due to lack of centralization. This condition is corrected to a large extent by the use of flow meters and skilled operators, but there is no more logic in men acting as governors in a boiler room than in the engine room.

The advent of forced draft automatic stokers opened the way for accurate boiler control. However, control systems applied to each individual boiler do not meet all the needs, though the improvement over no control is marked. Considerable attention is still necessary to keep each and every boiler up to its share of load and it has been found difficult to make all of the boilers immediately follow load changes. Some central power or governing means must control all the boilers individually and collectively. Then they will act as a unit, or as one large boiler with several stoker divisions. There results a saving of labor.

The application of automatic control involves not only design of a regulating apparatus, but also a careful study of boiler and stoker, or burner, characteristics for the selection of proper fans and drives. Fig. 2 shows the relation of stoker, forced-draft-fan and induced-draft-fan speeds to the load on a boiler. These curves can be plotted for any installation from calculations based upon boiler and stoker performance and fan characteristics. They show what the control system must do. It must maintain each of the auxiliaries at a given speed for each load and must do the same on every boiler operated. It must change the speed of the auxiliaries at the instant the load changes to the proper speed to meet the new load. In addition, in order to take care of varying fuel, there must be means provided to readily change the relation or slope of the curves in Fig. 2. This will permit changes in the thickness of the fuel bed and in the quantity of air admitted per cubic foot of fuel.

Individual Fans Advisable

The question of forced-draft fans has been given considerable study since the advent of the forced-draft stoker, and the application of automatic control opens a key for further study. When an ordinary plate-type fan is running at constant speed, a slight pressure change causes a large change in the volume of air delivered. In other words, a slight change in fuel bed thickness means a large change in the boiler capacity and this causes inaccuracies in control. With modern stoker fans, however, a small pressure change at its normal point of operation makes comparatively little difference in the air delivered. Therefore a slight increase or decrease in fuel-bed thickness makes little

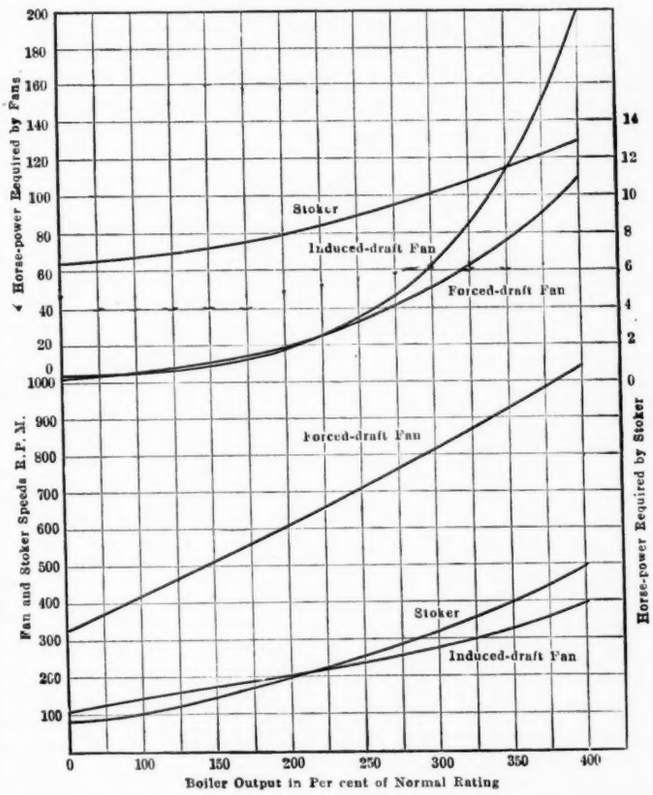


FIG. 2. POWER CONSUMPTION OF AUXILIARIES

difference in the boiler capacity. For boiler operation, fans having very steep pressure-volume curves should be selected, as they will function much more satisfactorily under a control system, whether hand or automatic. Individual fans should be used. Each boiler, then, has definite characteristics at all times, whereas with a common air duct, the number of boilers in operation varies the characteristics of the system and the compensating effect in keeping the fires in shape is not obtained. Thus if a hole should develop in the fire bed

and more air rush through, tending to enlarge it, there is a comparatively unlimited fan capacity back of this hole and the pressure is not reduced. There is, therefore, no tendency to fill up the hole and it enlarges until filled by hand. With individual fans, however, if a hole develops in the fire, there is a tendency to drop the pressure slightly, which means that less air will be forced through the preceding portion of the fuel bed. Since the coal feed is continuous, unburned fuel will, therefore, be moved forward to cover the bare spot. With automatic control, where speeds are definite and constant, and with individual fans, holes are corrected while still little more than a tendency.

Operation of Automatic Stokers

In the operation of automatic stokers, the feeding of the fuel and removal of the ash should be an almost continuous process and in proportion to the load. It has been often shown that, for any stoker set for a given fuel and rate of burning, there is a fuel bed thickness that is the most efficient. Therefore, some means should be provided to add fuel always just as rapidly as it is consumed and thus maintain the most economical fuel-bed conditions. Really the control system should not only supply fuel as needed but should also vary the fuel-bed thickness in proportion to the load. This last requirement has not yet been accomplished automatically and is a rather complicated procedure, especially where a rapidly-fluctuating load is encountered. However, it is possible and in view of the attention that is now being paid to boiler operation, it is quite likely to be taken care of automatically in the future.

Auxiliary Drives

The selection of drives for the auxiliary equipment calls for consideration of several questions. The driving units must have an easily adjustable speed control. The speed must remain constant for any given setting of the adjusting or controlling means. They must be reasonably economical. Formerly steam drives exhausting into the feed-water heater were used for auxiliaries. Lately, however, the tendency is to use a house turbine, driving a generator that supplies current to motor-driven auxiliaries. This gives the advantage of control of the exhaust heat by varying the load on the house turbine or by bleeding steam from or exhausting into the main unit. Motors may be held more closely to constant speed than steam-driven units under throttle control, and piping, both steam and exhaust, is replaced by wiring.

In many plants alternating current motors are used, chiefly so that they may be driven by the main units if necessary. The advantages of direct-current motor drives are economical and wide speed variation, ease of control, etc. It is the opinion of many power-plant engineers that the advantages of the direct-current motor drive in connection with boilers are so great that it pays to use them, even if a separate turbo-generator or motor-generator set has to be installed to supply the current.

One system of control seems to have met with considerable success. All of the auxiliary forced-draft fans, stokers and induced-draft fans are driven by direct-current motors. The armature current for each of these motors is taken directly from a common direct-current line supplied either by direct-current main units, motor-generator sets or house turbines. The fields of the motors are supplied from small motor-generator sets, one for each set of auxiliaries—that is, one for the forced-draft fan motors, one for the stoker motors, one for the induced-draft fan motors. The speed of each motor-generator set is controlled by a field rheostat, operated by a compensated steam-pressure-operated regulator, which moves the rheostat to a definite position for each given pressure. The regulator is connected to the steam main at or near the point of consumption. The pressure drop in the pipe causes the regulator and rheostat to move through the full range as the demand increases from no load to maximum load. The rheostat is so designed that for each position of the regulator, that is, for each load, it gives the correct motor-generator speed to produce the proper field voltage, so that the stokers and fans will have the correct speed to deliver the necessary quantity of coal and air to meet that load. Since all the stoker motors receive the same armature and the same field voltage and the forced- and induced-draft fans likewise, all the boilers carry the same load and change their rating at the same time. The control for any number of boilers on the same load is centralized in one regulator with its motor generator set. The operation of a large number of boilers is thus reduced to the terms of one and that one is taken care of automatically as far as combustion is concerned.

To provide adjustment for varying fuels, a hand-operated rheostat is inserted in the field of the generator of each motor-generator set, by means of which the relation of coal feed to air supply can be varied. For adjusting each individual boiler to its share of the load and to compensate for any slight difference in the characteristics of various boilers and stokers, there is a hand-operated rheostat provided in the field of each stoker and fan motor. Hand control for starting or in case of emergency is provided by means of a double-throw switch on each boiler. This cuts out the motor-generator set and connects the fields of all motors directly across the line through hand-operated rheostats, which give full speed range.

Draft Control

The question of draft control is open to much discussion. Draft is necessary to move the gases through and out of the boiler and to protect the brick work. At the same time it must not be so intense as to cause an unnecessary air infiltration or so low as to permit the pressure to rise in the combustion chamber, for this is detrimental to the brick work and is uncomfortable for the fireman, who must observe the fires. It has been found in large boilers with high combustion chambers that there is enough draft effect in the combustion chamber to cause an appreciable negative pressure in the lower part, while there is a balanced-draft condition at the top or even in the second pass. Up to the present time, the tendency is to keep the draft in the combustion chamber constant at a slight negative pressure, by means of a regulator controlled by the furnace pressure and either operating the damper or changing the speed of the induced-draft fan. With the control system just described it is possible so to design the induced-draft fan generator that an increasing combustion-chamber draft is secured. For damper control, however, nothing has yet been offered commercially along this line, although the automatic control of the combustion-chamber draft and avoiding excessive air infiltration is one of the simplest and easiest means available for saving fuel and labor.

EDITORIALS

Power in the Industries

OUT of a total of ninety-six thousand industrial establishments in the so-called Superpower Zone, seventy-six thousand are dependent upon power for their manufacturing processes and represent in the aggregate over nine million horsepower capacity. This is exclusive of steam and electric railways and central-station lighting loads. Such is the magnitude of the figures revealed by the latest census and interpreted by Mr. Goodwin in this issue in the light of the recent Superpower investigation. Mr. Goodwin's analysis is worthy of careful study not only by the economists, but by everyone whose business concerns the production, the application or the sale of power or power equipment.

Covering, as they do, the greatest industrial section of the country, the figures not only emphasize the importance of power in our industrial life, but also serve to rectify some preconceived notions founded on less extensive and less authentic information. For instance, we have been prone to look upon the large number of small plants as the great offenders in fuel waste. Yet, when it is considered that they account for only eleven and a half per cent of the coal used, they assume relatively small importance. There are over seventy thousand of these plants under two hundred horsepower, averaging twenty-one horsepower apiece, three-fourths of which are operating on purchased power. Of the remaining sixteen thousand which generate their own power, the average is only forty-eight horsepower per plant. Obviously, the greater number of these must be under that figure or in many cases too small to warrant a private plant.

Of the total industrial power used in this zone two-thirds is privately generated and one-third purchased. Eighty-three and a half per cent of that generated is in plants of over two hundred horsepower or seventy-four per cent is in plants over five hundred horsepower; whereas forty-seven per cent of that purchased is in plants under two hundred horsepower.

Mr. Goodwin analyzes the coal consumption of these large plants and suggests how a considerable saving in coal might be effected through electrification, although thirty-three million tons, or sixty-two per cent of that now used, would still be required for the industrial processes and heating.

Again, there is a popular idea that the steam engine is becoming a thing of the past; yet, of all the prime movers installed, exclusive, of course, of those in central stations, steam engines account for approximately sixty-eight per cent of the horsepower, steam turbines nineteen per cent, waterwheels eight and one-half and internal-combustion engines four and one-half. The statistics show a decrease in both the number and aggregate horsepower of waterwheels in industrial plants, due to the taking over of water powers by central stations and the replacement to a large extent, of the small, inefficient wheels with the larger and more economic units.

Utilizing Waste Heat

IT HAS been said that "no adverse condition is so bad but what some gain results." This statement can be very appropriately applied to the fuel situation during the last few years. From the humblest city home to the largest industries, be he laborer, engineer, captain of industry, millionaire, or what not, everyone has been made to realize the effects of a fuel shortage and high prices and how important fuel is to our existence. This has resulted in attention being focused on how wastefully fuel has been utilized in the past and what might be done to develop more economical methods of using heat. One of the manifestations of this is the effort being centered on utilizing the waste heat.

In many industries large quantities of fuel in various forms are required in the processes, the gases from which contain thirty-five to eighty per cent of the heat in the fuel. It has been only within comparatively recent years that effort has been made to utilize this heat, and this effort has been confined chiefly to using blast-furnace gas under boilers or in gas engines. In burning this gas, large wastes have existed either by allowing part of the gas to pass to the atmosphere or by uneconomical methods of combustion. But serious consideration is now being given to more economical methods of utilizing this gas.

There are many other sources of waste heat from the different furnaces in the steel industry that up to the present time have been allowed to go to waste and coal used to generate power or the power purchased from a utility company. Although business depression has retarded new projects, there is a decided interest in utilizing these sources of waste heat for power purposes, even to the extent of using the exhaust from gas engines.

In the cement industry it has generally been considered that purchased power was the best solution of this problem, but all the time the waste heat from the kilns was sufficient, if properly utilized, to supply a large percentage of the power required for the plant. There are now a number of waste-heat boiler and power installations under consideration for cement mills, which will be followed by others.

Many other industries have waste heat that can be economically utilized and undoubtedly will be when the problems involved in such applications have been satisfactorily worked out. In addition to these industrial processes in which waste heat is a byproduct, there are many that require low-temperature heat, usually in the form of steam or hot water, which can be most economically supplied in the form of exhaust steam from a turbine or engine operated to generate power from the higher-temperature range of the steam.

During the war and for a period after there was a decidedly adverse feeling by the management of many industries against operating a power plant, on account of labor and fuel difficulties. These problems are gradually being solved. The high price of fuel, where it is in use in processes, makes it all the more important that

the greatest possible use be made of it, and industries are beginning to look toward the installation of a power plant as a means to this end. Many of these industries offer special problems in the generation of power from waste heat and will require close co-operation among the power-plant engineers and power-equipment manufacturers, and also the industrial-process engineers. When these applications have been developed to the fullest, the industrial power plant will occupy an even greater position than it does today in the large industries.

Muscle Shoals Negotiations Difficulties in the

FOR several years the Muscle Shoals power development has been the football of politics. It has been not only a question of party politics, but also one of sectionalism in its most aggravated form. Aside from this difficulty two new problems are presented in the consideration that is being given by the Federal authorities as to the disposition of the partly completed plant. One is purely a matter of public policy, the other a matter of engineering judgment; but both are of concern to the engineering profession.

The best offer thus far received by the Government for this partly completed project is that from Henry Ford, which has been given such wide publicity. Informal negotiations or proposals from other sources have been discussed, but only this one is taken seriously, it seems.

The proposal by Mr. Ford contemplated a one hundred-year lease with privilege of renewal by the lessee at his option. This proposal, it would seem, is contrary to the well-established water-power policy of the Government, which has developed after many years of effort to bring upon a fair common plane the demands of the conservationists and the ideas of those who urged widespread development. There is a natural hesitancy on the part of Government officials to consider seriously a proposal to lease what promises to be one of the largest developments of cheap power in the world without adequate provision for recapture by the Government and control by the proper public authorities both as to additions to the present facilities and conditions under which the power will be used or made available to the public. Whether an insistence upon these principles, which are essential under our present Federal power policy, will make the project unattractive to Mr. Ford, one can only surmise.

The second serious problem before the Secretary of War and his associates is the question of the engineering estimates which have been made as to the necessary additional expenditures to complete the project. Mr. Ford's offer appears to indicate that he assumes that twenty-eight million dollars will be adequate to complete the Wilson dam to a capacity of six hundred thousand horsepower and to erect dam No. 3 and equip it to a capacity of one hundred and twenty thousand horsepower. The Government's engineers have variously estimated the cost for the Wilson dam alone as thirty-three million dollars, depending upon the unit costs and upon the completeness of power-plant facilities which are considered. On a comparable basis of cost dam No. 3, which is about the same length and approximately half the height, is believed to represent an additional requirement of nearly, if not quite, twenty million dollars. Thus the Government engineers, who would have to do the work if completion is arranged for, think they should be provided with nearly twice the sum which Mr. Ford's offer contemplates. And the offer that Mr. Ford makes, if accepted, would commit the Government to completion of both power properties to the capacities named, without regard to what this might cost the Government.

Obviously, this is a serious and probably an unjustifiable difference in estimates of cost. Surely, the Secretary of War can expect that experts in this field should agree more nearly than this before he gives serious attention to the questions of policy that are involved. It is an unfortunate implication of incompetence upon the engineering profession at large if these two estimates cannot be revised to be much more nearly in harmony. Construction conditions at Muscle Shoals have been subject to detailed study in the course of many months' actual work. Unit costs should have been well established and changing market conditions should be easily appraised with an accuracy far greater than the foregoing discrepancy would indicate.

Muscle Shoals, properly developed, would afford industrial power on a large scale that is perhaps to be comparable in cost with the power at Niagara. It would be a real step forward to have this project completed if it can be done along sound engineering and economic lines. The major question of public policy should not long remain one of serious difficulty if Mr. Ford or any other industrial leader of large means is willing to co-operate upon the present well-established basis of power development subject to Federal and state control in important particulars that concern public welfare.

The Crude-Oil Situation

FOR several months the general industrial situation has influenced the demand for crude petroleum to such an extent that the price to the refiner has been below the cost of production. The decrease in the demand for petroleum distillates lowered the price of boiler oil to a point where, on a heat-unit basis, oil became cheaper than coal and has been favored in certain districts for power-plant fuel.

This led to extensive alteration in many power plants where stokers and coal-handling equipment were abandoned in favor of the simpler oil-fuel apparatus. Of additional attractiveness were the lowered boiler-room labor charges and the increased boiler efficiency.

In the last few days crude oil in the mid-continental field has advanced from one dollar to one dollar and fifty cents per barrel. This increase is to some extent based on rumors of Mexican wells going to salt. Actually, the rise is a natural result of the increased industrial activity apparent on all sides.

It is not possible, nor is it wise, to offer a prediction as to the future course of the crude-oil market. While there is every reason to expect a gradual upward trend in the prices of all petroleum products, how far this will progress is unknown, nor is it possible to determine how long oil will be available for boiler fuel. Power-plant managers who are contemplating a conversion from coal to oil should give considerable study to the question of supply and probable cost. In all events it would seem judicious to make no alterations in boiler setting which would prevent a quick change back to coal in case the oil supply is cut off or the price is advanced to a point where coal becomes the cheaper fuel.

CORRESPONDENCE

Why Do the Lights Flicker?

What is the reason that the electric lights in the factory flicker? The engine is a high-speed unit and is directly connected to the generator. It is suspected that the trouble is due to the flywheel-governor adjustment, but after several examinations nothing has been found out of order.

Can any engineer who has had experience with high-speed engines suggest a remedy for the trouble?

Albany, N. Y. W. J. GROOM.

Mysterious Fuse Failures

While talking shop with one of my neighbor engineers recently, he told me of a case in his plant where the fuse blew on one of the main circuits, which supplied a number of sub-feeders to the lighting system. The cause given was that all the switches on the sub-feeders were closed and the rush of current to the lamp was sufficient to blow the fuses. The contention was that the lamps take considerably more current when they are first connected to the line than when the filaments become heated to the normal operating temperature. Although this is true for metallic-filament lamps, nevertheless the duration of the peak is not long enough to blow the fuses even if the circuit is only fused to the normal rated load.

The resistance of carbon-filament lamps when cold is about double what it is when hot. In this case when the switch is closed, even if the current were influenced by no other factor than the resistance of the circuit, it could not be any more than half normal value. Before the current has had time to increase to half value, the filament is heated, causing its resistance to decrease, and the current comes up to normal value, but no higher. This all takes place within less than one second.

The cold resistance of a tungsten filament is approximately one-eighth that of the hot resistance, so that theoretically the inrush current should be about eight times normal, but other factors enter into the problem and the current reaches only around six times normal. However, within 0.01 sec. this current has decreased to only two times normal, and in about 0.03 sec. normal value is reached.

A standard N.-E. code inclosed fuse will carry 300 per cent normal current for approximately ten seconds before blowing. Therefore, it is evident that the inrush caused by throwing a load of tungsten lamps on the circuit cannot blow fuses, even if the circuit is loaded up to their rated capacity. Even if the circuit's connected load was equal to the normal capacity of the fuses, it would be a rare condition to find all the lamps turned on at the instant of closing the switch. Consequently, it would be an exceptional case where the switch would be closed at a time when the connected load equaled the rated capacity of fuse, and even if it were the duration of the peak is not long enough to cause the fuse to fail.

Not infrequently, fuses fail when no particular cause is apparent. However, this is generally due to a defective fuse or connection or to the fuse being weakened at some previous time by trouble on a circuit that was cleared before the fuse failed. A ground or short-circuit may exist in the conduit somewhere on the system and when the switch is closed the blowing of the fuses burns the fault clear, consequently no outward indications remain to tell the cause of the fuses blowing. It is my opinion that where fuses blow without any apparent cause, it is due to some condition such as outlined in the foregoing and not to the inrush of current to the lamps on the circuit. M. A. WALKER.

Boston, Mass.

Expanding Boiler Tubes

Retubing a return-tubular boiler or replacing a few tubes is a job that may fall to the lot of an engineer at most any time, and in some instances the work may be found more difficult than may be anticipated.

In one case it was necessary to remove several tubes from a boiler. When the ends had been loosened in the tube sheets, it was found that the scale on the tubes was so heavy that they would not come out through the holes in the front head. As a result it was necessary to hammer the tubes and work them out a few inches at a time, thus prolonging the work.

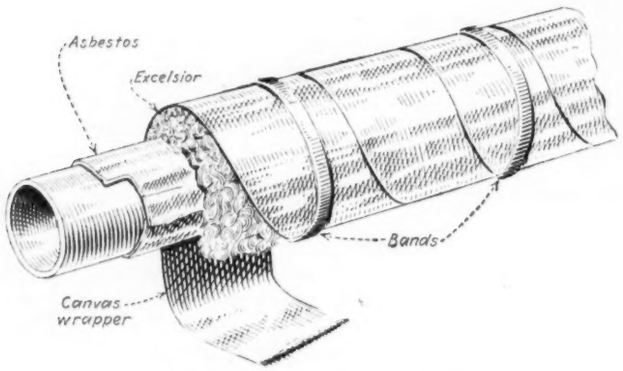
Having removed the tubes, it may be found that the new ones fit too loosely in the tube holes. In such a case put a narrow strip of sheet copper or galvanized sheet iron around the tube where it fits into the head, the strip ends overlapping and hammered to a bevel before being put in place. If the tube hole is still too large, then a larger tube should be used. However, a boiler tube of good material will stand a lot of expanding before it will show any signs of splitting.

Some tubes will split when expanded so as to grip the tube sheet. Sometimes annealing the tube ends will not prevent the trouble. In such cases a strip of copper or sheet iron should be placed around the tube end, which prevents excessive expanding.

Philadelphia, Pa. T. P. SAUER.

Home-Made Pipe Covering

There was a length of piping, the old covering of which was subjected to knocks from this and that until not much of the insulating material was left in place. This meant a loss of heat. As the plant was in an out-



HOME-MADE PIPE COVERING

of-the-way place, it was decided to make a home-made pipe covering, which did not cost as much as the purchased article.

First, the pipe was wrapped with a piece of asbestos paper and then well wrapped with a layer of excelsior, tightly packed, over which were wound strips of canvas secured in place with thin, flat metal bands. The canvas was then painted. The excelsior forms a dead-air space which is a non-conductor of heat.

Cincinnati, Ohio. R. P. JACKSON.

Changed Oil Cured Hot Bearing

The communication by A. L. Drew, page 499 of the Sept. 27 issue, brings to mind a case of hot bearing on a Brush arc machine some years ago. My shift was from midnight until noon, and when coming on duty the bearing on this machine was reported as running hot. One could hold a hand on it, but that was about all. During the remainder of my watch it kept getting hotter and when the machine was being shut down a thin film of smoke could be seen coming from the bearing, which was of the ring self-oiling type.

As the trouble was not due to lack of oil, it was thought that it was caused by foreign substances of some kind in the oil. The bearing was therefore drained and thoroughly washed out with kerosene oil, and then refilled with new bearing oil. That night it ran as smoothly and cool as usual. C. P. GARVIN.

Pittsburgh, Pa.

Treating Hot Bearings

Every engineer has doubtless had experience with hot bearings, and the larger they are the more anxiety they cause if heating develops. Babbitt, with a certain degree of heat, expands quickly. If such a bearing begins to heat, the first thing to do is to slacken up on the cap bolts, also the quarter boxes, if there are any.

On large bearings it may be necessary to relieve the shaft of the weight of the cap, so as to remove all unnecessary friction. Some caps are provided with screw bolts for the purpose of raising the cap. In the absence of such, a piece of flat iron may be placed under the cap on both sides.

Having relieved the friction of the bearing, apply plenty of cylinder oil that has a high flash point. This will reduce the temperature of the metal, as loosening the quarter boxes and the cap gives the metal a chance to expand and the oil helps to absorb the heat.

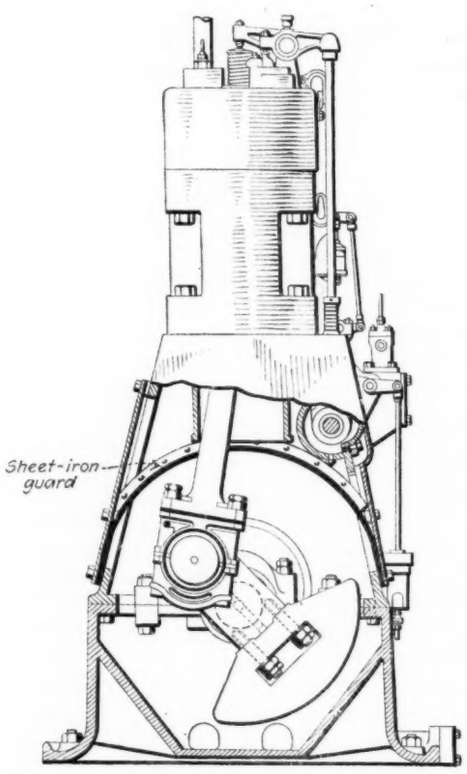
Having arrested the heating, remove the cap at the first opportunity and clean out the oil grooves so as to make sure that they are not stopped up, and wash out the bearing with kerosene. It is a good plan to wash out bearings at least twice a month. This can be done by feeding through the oil cups, if the engine is so equipped, or by flooding through the oiling system.

Cleveland, Ohio. A. P. JAMESON.

Oil Shield for Gas Engine

Every engineer who has operated a vertical gas or oil engine has had experience with the lubricating oil entering the cylinder from the crankcase. No matter what system of lubrication be used—splash, gravity or pressure feed—the crankcase is at all times fairly filled with a fog of lubricating oil. This oil splashes onto the piston and cylinder walls and is carried up into the combustion space. Excess lubricating oil will produce carbon in the cylinder, and is one cause of preignition.

In an engine under my care this lubrication difficulty became so bad as to prevent steady running of the engine. To keep the oil in the crankcase from splash-



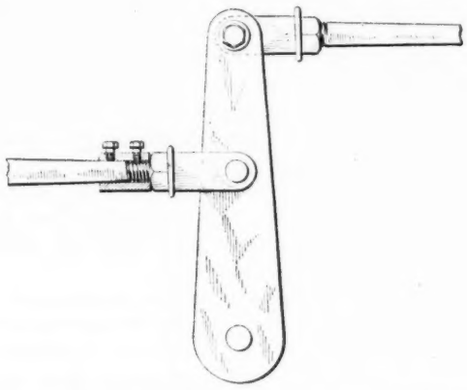
CRANK OIL SHIELD

ing, I made the oil shield shown in the illustration. These shields were placed over each crank throw, and were stiffened by a small angle iron. The ends were drilled and slipped over the screws holding the doors. In this way it was no trouble to remove them when inspecting the cranks. These shields freed the engine from all difficulties caused by the lubricating oil.

New York City. E. E. LONG.

Emergency Eccentric-Rod Repair

The eccentric rod of a small Corliss engine recently broke because of a flaw in the metal just at the end of the threaded portion next to the rocker arm. It meant a big loss to the company if the engine was shut down



HOW THE ROD WAS TEMPORARILY REPAIRED

for much more than an hour, because of spoiling the material in the process of manufacture.

The eccentric rod was a scant 2 in. in diameter at the point of fracture. A piece of extra-heavy pipe about 5 in. long was turned on the inside to fit, and two holes were drilled 2 in. from the end of the sleeve and tapped for ⅝ in. hardened setscrews. When ready, the sleeve was placed on the rod and the broken ends brought together as closely as possible and the setscrews firmly tightened, the ring forming the cup and the end of each, cutting into the metal of the rod.

The engine ran for two days with this repair, and on Saturday afternoon the rod was welded and was ready for starting up Monday morning.

Camden, N. J. E. A. JESSUP.

Adapting 25-Cycle Desk Fan to 60 Cycles

An occasion presented itself recently when an industrial plant desired to move a number of surplus electric fans to one of its branch offices out of the city. The frequency of the power generated by the plant was 25 cycles, and that in use in the branch office was 60 cycles. The motors are of the series type and do not operate very satisfactorily with a frequency range greater than 10 or 15 per cent.

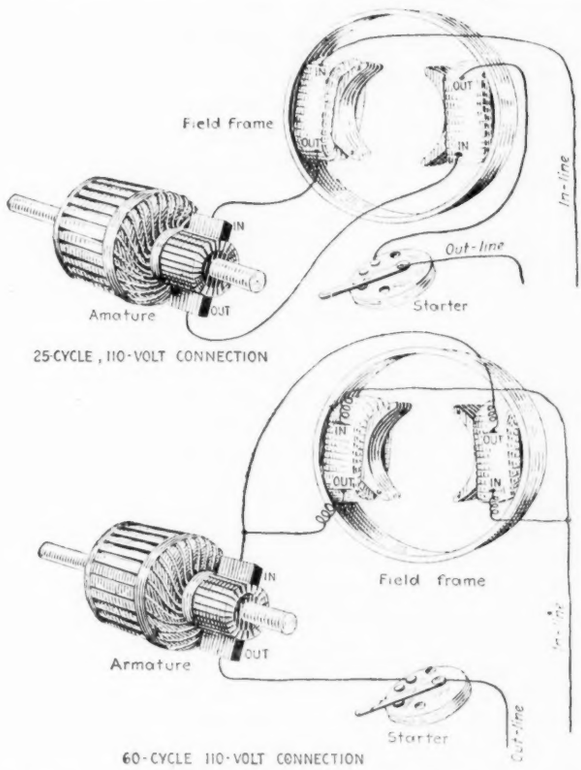
In order to utilize the motors it became necessary either to rewind the series coils or else to reconnect these coils. From the usual formula, given here, for voltage changes on induction motors when the frequency is changed, we found that instead of 110 volts the equivalent of 170 volts would be required to run the fan up to speed, with the original connection.

$$E_2 = E_1 \sqrt{\frac{F_2}{F_1}} = 110 \sqrt{\frac{60}{25}} = 170 \text{ volts.}$$

Where E_2 equals new operating voltage, E_1 equals original voltage, F_2 equals new operating frequency and F_1 equals the original operating frequency. Consequently, it was decided to parallel the two field coils and operate the armature in series with the multiple connected fields as shown in the bottom arrangement in the figure. The motors when operating with this connection show about the same behavior as when operating with 5 per cent overvoltage with 25 cycles and the original connections.

I do not believe that any lower frequency than 60 cycles could be used with the paralleled fields in our case on account of excessive heating unless some sort of choke coil be inserted in the circuit to lower the impressed voltage. We have also in another case taken the direct-current series fan motors having laminated field frames and used them with entire satisfaction on 25-cycle lines by paralleling the field coils, as outlined in the foregoing.

In making the reconnection it is only necessary to retain the relative polarities of the coils and armature as they were originally. This is easily accomplished by tracing the circuit from one line to the other line through the motor. Where the connections enter a field coil or armature, that point should be marked "in" and where the lead leaves the same field coil or armature it should be marked "out." By maintaining this plan of tracing the circuit "in" and "out" when reconnected,



MOTOR CONNECTIONS BEFORE AND AFTER CHANGE IN FREQUENCY

it is easy to secure the proper polarity of the fields and to have the fan operating in the proper direction.

East St. Louis, Ill. J. E. HOUSLEY.

[When the frequency is changed on a motor, the voltage may be changed to produce two effects—one to keep the magnetic conditions in the motor the same and the other to vary the magnetic flux approximately inversely as the frequency. If it is desired to keep the magnetic conditions in a motor exactly the same, the voltage should be varied in the same direction and by the same amount as the frequency. This keeps the same flux density in the iron, and with the same current in the windings the result would be the same torque since the torque is proportional to the product of the magnetic lines and the current in the conductors.

However, since *horsepower* = *torque* × *r.p.m.* ÷ 5,250, and since the speed of the motor changes as the frequency, the result is that the horsepower will vary directly with the speed, which means that it varies as the frequency varies. Stating this another way, if the frequency and the voltage are changed together in the same direction and by the same amount, the motor develops constant torque, or would have the same torque rating at all times, but a varying horsepower rating. Mr. Housley's statement is calculated to preserve a constant horsepower at different frequencies and speeds. In order to accomplish this, the motor torque must vary inversely as the speed varies. In other words, less torque will be developed at the higher speed and more torque at the lower speed, and in order to keep a constant horsepower at the different frequencies, the magnetic conditions in the motor must be changed. To accomplish this, it is approximately corrrect to change the voltage as the square root of the change in frequency.—EDITOR.]

Engineering Reminiscences

Much is written these days of modern methods of operating steam, electric and hydraulic machinery, and the young engineer would be somewhat surprised to know of some of the things the "old-timers" occasionally ran up against. Back in the 90's, I was engaged as chief engineer to take charge, at the munificient salary of $20 per week and meals, of the plant in a hospital in New York. The former chief, I afterward learned, had left because of the interference of the assistant superintendent, who also had charge of the drug department. The first day on the job an inspector from the Police Department called and asked to see my license, saying that the department had been notified that the plant was being run by a drug clerk.

The hospital occupied a city block. There were four 60-in. by 16-ft. horizontal-tubular boilers. One had two bags in the front sheet over the fire. Two of the others had leaky tubes. There were five "leak-stoppers" on the feed-water line between the pump and boilers. There was a vertical feed-water heater with a split coil, which was choked with grease and mud. For engines there were in one room four of various sizes. In another room was a slide-valve engine for running the laundry, two house pumps, and two feed pumps. In still another room at the foot of a fresh-air stack, was a slide-valve engine that ran two 6-ft. fans for the ventilating system. All this equipment was adjacent to the boiler room. In another part of the cellar were two elevator engines. Off on another corridor, 200 ft. from the boilers, was a compound-duplex pump for the hydraulic elevator, and in the next two days during my exploration of the cellars I ran across two 8- x 10-in. engines, belted to fans; also an upright engine used for the same purpose. Later, I found tucked away in a dark corner, a 4- x 6-in. engine that had stopped for want of oil.

The fireman on the day shift was a new man, and on the fourth morning he came to me and said "Boss, come out to the fireroom, I'm through." I went, and found a man's leg on a barrow of coal. A short session with the superintendent ensued. He said, "We have no incinerator and all that material must be burned in the furnaces." He hinted that he thought both the fireman and myself were rather thin-skinned, but issued an order that all material of that kind should be wrapped and that the orderlies should put it in the furnace.

Most of the equipment had been in service many years and was sadly in need of repairs and renewals, but the management were disinclined to spend any money on the plant, and most of my requisitions were turned down with the excuse that they were contemplating installing a new plant. They had had that under consideration for over five years. For a start I got boilermakers, and the bags on No. 1 boiler were heated and bumped back in place. About forty new tubes were put in Nos. 3 and 4 boilers. The guards and studs were found burned off three of the handhole plates in the rear, only pressure holding the plates in place. The blowoff pipes were plugged and, after cleaning them, steam was taken from the highest point through a ½-in. pipe that was tapped into the blowoff, behind the cocks, and by blowing steam through the pipe every time the boilers were blown down they were kept free.

While putting a new coil in the feed-water heater, it was necessary to have light, as in certain other parts of the building where gas was not available. There were electric ambulances, which were fully charged before shutting down Sunday morning, and by "plugging in" an ambulance we obtained all the light needed.

One engine was comparatively new, but the cylinder casting was soft and badly worn out of round. It was rebored and a new piston fitted. The old slow-speed blower engine had lignum-vitæ crosshead shoes. They were worn out and as new ones were unobtainable, a pair of white oak were made which answered the purpose.

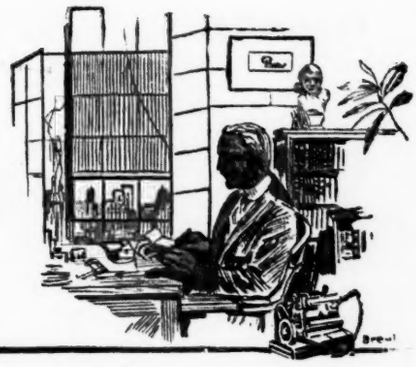
Much of the work was the replacing of worn-out piping, and there was plenty of it. Some of it had been laid in the concrete floor of the cellar years before, leaving only a rusty hole in the concrete for the steam, water, or maybe gas to flow through. One worry was the lack of a grease extractor on the exhaust line, as exhaust steam was used for heating and there was no provision made for keeping the cylinder oil from going to the boilers. Regardless of how often they were blown down and washed out, there would always be considerable oil in them. Finally, the house carpenter built a filter box, of 2-in. pipe, 2 ft. x 2 ft. x 10 in., with five partitions, about 19 in. apart. The opening in the first partition was at the top, the next one at the bottom and so on. These openings were screened with ¼-in. wire mesh. The 3-in. pipe between the return tank and the feed pump was cut and the box set so that the water from the tank would flow into the first compartment and the pump would take it from the last one. A fresh-water line was run to the last compartment and fitted with a ball-cock to keep a constant water supply. The compartments were filled with excelsior, and by renewing it two or three times a week it was possible to catch most of the oil.

Within a year after leaving the hospital to take another position, they did start to install a new plant. A visit was made there after it was completed, and what a change! There were larger water-tube boilers, two Corliss engines, direct-connected to generators, and all the latest improvements, including an incinerator and a grease extractor. Everything was motor-driven throughout the hospital. The engine room was a work of art; a marble switchboard, polished slate walls, and a skylight covering the whole room. As my eyes roamed over the various recording and draft gage, modern damper regulator, etc., I could not help thinking what a comfortable job it was compared to the former condition of things.

M. M. BROWN.

Camden, Me.

INQUIRIES OF GENERAL INTEREST



Treatment of a Bent Boiler Stay—What should be done in case a boiler stay is found to be considerably bent? T. W.

Unless through stays are supported near the middle of their length, they will sag considerably from their own weight. When a stay is bent, it cannot be of the full value for which it was intended for bracing the boiler. Such a stay should be removed, straightened and upset if necessary for shortening it to the proper length for resetting while warmed up.

Current Rating of Rewound Generator—A 250-kw. 2,200-volt three-phase generator, whose full-load current rating was originally 66 amperes, has been rewound for 240 volts. What current can the machine safely carry under this voltage? M. D.

If the machine has been correctly rewound, its capacity in kilowatts remains practically unchanged, and the amperes therefore vary inversely as the voltage. Hence, the formula is:

$$\textit{New amp. rating} = \textit{Old. amp. rating} \times \frac{\textit{Old voltage}}{\textit{New voltage}}$$

$$= 66\ \textit{amp.} \times \frac{2200}{240}\ \textit{or}\ 605\ \textit{amperes}$$

Manholes in Heads Below Tubes in H. R. T. Boilers—Why are not manholes placed in the heads below the tubes in smaller as well as larger horizontal return-tubular boilers? M. C.

Manholes placed in the heads below the tubes are desirable as means of access for cleaning, inspection and repair of the interior of the boiler, particularly the bottom of the shell. But for a boiler less than 48 in. in diameter, a manhole below the tube takes up a large proportion of the tube sheet area, and to employ an appropriate number of fire tubes would require the upper rows of tubes and water level to be so high as to make the steam space smaller than desirable.

Compensating Chains on Elevators—What are compensating chains or cables and why are they essential for the satisfactory operation of drum-type elevator machines? F. A. A.

When an elevator car is at the bottom landing, the counterweights are at the top of the hoistway. Under this condition the length of the car-hoisting and car-counterweight cables is added to the weight of the car and the length of the counterweight cables down the shaft is deducted from the counterweights. With the car at the top landing the weight of the cables is transferred to the counterweights. In high-lift installations the weight of the cables is considerable and when transferred from car to counterweights or vice versa makes a material difference in the counterweighting of the car at the top and bottom landings. To compensate for this difference, cables or chains having the same weight per foot as the cables to the car are connected from the bottom of the car to the counterweights. When the car is at the top of the hatchway, practically the total weight of the compensating chains will be hanging from the bottom of the car, thus compensating for the weight of cable transferred to the counterweights. With the car at the bottom of the hoistway practically the total length of the chains will be hanging from the counterweights, thus compensating for the weight of cables transferred to the car, and in this way maintaining the counterweighting constant.

Compensating chains are not essential on all drum-type elevators; in fact, practically all low- and medium-lift machines are operated without them. It is only on high-lift machines that compensating chains or cables are used to prevent their being a considerable difference in the counterweighting at different positions of the car in the hoistway, and then their application is in general limited to passenger-type machines. The use of these cables or chains makes it possible to obtain smoother stopping of the car and to adjust the counterweighting for the most economical operating condition.

Laying Up Boilers for a Long Time—We have two 72-in. diameter horizontal return-tubular boilers that may be out of service for several years. What is the best method of keeping them in shape while they are not in use? J. E. L.

Precautions should be taken to preserve the material from rusting caused by deposits of moisture. Any rust already inside or outside of the boiler should be removed as far as possible by thoroughly scraping the parts. The boilers then should be cleaned and washed out and, when dry, should be painted with genuine red lead along edges of joints, along rusted water lines and around tube ends and joints of any connections that are screwed into the shell or heads of the boilers; also spot with red-lead paint any other places where the rust is too deep to be completely removed. When the red lead has dried, close up the boiler and place in the bottom of the shell about 10 gallons of heavy oil that is free from sulphur or other corrosive ingredients. Then fill the boiler to overflowing, preferably with warm water. The water may now be drawn off and every part of the interior will thus become coated with a film of oil. Manholes and handholes should be left open long enough for the oil coating to become fairly dry. Then to prevent circulation of air, the boiler should be closed up with an upper manhole closed from the outside. The vapor arising from oil thus spread over a large surface is likely to combine with air and form an inflammable mixture. After the surface has thus been oiled and until the boilers have been boiled off with soda ash, it is dangerous to enter the boilers or have a live flame like a lighted match near openings.

The fire tubes should be scraped or brushed out clean and swabbed with oil, and as an additional precaution against circulation of air through the tubes, they should have their ends plugged with newspaper. Clean the exterior of the shell and heads and, as far as practicable, give them a coat of asphalt or graphite paint. Remove all ashes and soot, close off dampers tight with paper or bagging, and keep fire, ashpit and cleaning-out doors closed tight. Clean the smoke-pipe connections of soot and loose rust. They should be disconnected from the chimney and stopped off to prevent air circulating through them. When the interior surfaces are thoroughly cleaned, a coating of lime and cement wash, applied with a brush, makes a good preservative for smoke connections in or out of use, and exterior surfaces can be protected by a coat of graphite paint.

Penstock Bursts in High-Head Plant

The Hydro-electric plant known as Big Creek No. 8,[1] which was recently completed in California by the Southern California Edison Co., was put out of commission on Aug. 20 for twenty-three days by the bursting of the penstock at a point about 200 ft. from the power house. The break occurred immediately after a short-circuit on the transmission line that caused a surge in the penstock, and the fracture occurred in a steel manhole casting which proved, on later examination, to have a defect in the form of a slag pocket. Because of the solid rock and well-founded concrete saddles supporting the pipe where the break occurred, neither the shape nor the alignment of the penstock was disturbed on either side of the section that burst, though the upper part collapsed under external pressure as the water rushed out. The break was repaired by cutting out the damaged portion with a torch and fitting into place a sleeve which was then riveted to the two open ends after the necessary rivet holes had been drilled. The section removed was about 19 ft. long.

The Big Creek No. 8 plant operates under a head of 680 ft. and has a penstock 2,800 ft. long varying in inside diameter from 8 ft. at the top to 6 ft. at the power house, and in thickness from $\frac{3}{8}$ in. to $1\frac{7}{8}$ in. The upper part is riveted pipe, the lower part hammer-welded, with riveted joints between sections. The rupture occurred one length above an expansion joint in the welded pipe, and passed close to a manhole casting on the upper side of the pipe. The static head at this point is about 560 ft.

The single unit installed at this plant has a capacity of 22,500 kw., but up to the time of the accident it had not been carrying a load in excess of 15,000 kw. The plant had been under tests for four days and on the night previous to the break was put on governor control for the first time. The unit was then developing approximately 10,000 kw. and was operating at about $\frac{1}{5}$ gate opening.

As nearly as the facts can be established from available data, at the time the short-circuit occurred, shortly before 6 a.m., the gates opened and the unit took on an additional load; some accounts estimate this additional load as high as 10,000 kw. Immediately thereafter, it is stated, the short cleared itself and the turbine gates closed.

Attendants at the plant describe the rupture of the pipe as a progressive occurrence. With the first report, presumably marking the first escape of water through the weak spot of the manhole-ring casting where the slag pocket was later found, a small stream of water, apparently from the top of the pipe and under extremely high pressure, shot high in the air and passed entirely over the power house. This was followed by a rapidly broadening stream of larger volume that struck the temporary end wall of the power house squarely and swept into the structure. The broader stream is believed to have marked the longitudinal ripping of the pipe, which occurred for a length of 8 to 10 ft. Later still a circumferential tear laid the ruptured section wide open. In its final position this portion of the side wall of the pipe was almost flattened down on the ground. The circumferential tear and the large opening it caused were on the side away from the power house so the larger volume of water was diverted away from the structure during the remainder of the flow.

Gages and other instruments in the plant were damaged by the stream of water entering the plant, so that complete operating data are not available. It is stated, however, that the short-circuit caused a sudden draft of water resulting in a drop in pressure in the penstock of about 30 lb. per sq.in., which may have caused a break in the water column. On this analysis the closing of the turbine gates, upon clearing of the short circuit, retarded the lower water column to such an extent that it was rammed by the upper water column, thus producing a destructive pressure rise.

When the break occurred the plant was operating without forebay or surge chamber. Construction on that feature of the development had not been completed, and a bypass or temporary direct connection between tunnel and penstock was being used. This connection consisted of a 6-ft. pipe and was about 150 ft. long. The air-vent at the upper end of the penstock consisted of a 6-in. pipe.

At the time of the break the sudden release of water under spouting velocity emptied the pipe quickly, collapsing the riveted pipe at the upper end of the penstock for a distance of approximately 450 ft. The collapsed section of the pipe has since been restored to approximately the original shape by filling the pipe and subjecting it to a slight additional pressure, a temporary bulkhead in the lower end of the collapsed section being used meantime to hold the water. This collapsed section extended down to an expansion joint in the first length of welded pipe. The expansion joint was pulled open by the collapse of the pipe above.

The line of break of the ruptured section of pipe passed along the manhole-ring casting, but did not cut across the ring. Except at this manhole the break did not follow welded joints, but went through the metal.

Samples taken from this joint, as also from other parts of the fixture, were examined by the New York Testing Laboratories. Their report on microscopic study of the samples states that both plate and casting are of excellent character, but that just at the slag pocket the casting has a large-mesh structure of decidedly weak type, and many slag inclusions.

The pipe had passed both shop and field pressure tests before the plant was put in operation. In the shop tests each length was subjected to 50 per cent excess of pressure over the final static head. In the field the penstock as a whole, after completion, was tested under full static head. No difficulties or weaknesses developed in these tests.

[1]For description of units see *Power*, Aug. 16, 1921.

Idleness in the Coal Mines

The present condition in the bituminous-coal mining industry is well brought out by the accompanying chart, which was prepared by the United States Geological Survey. Most of the figures upon which the chart is based represent

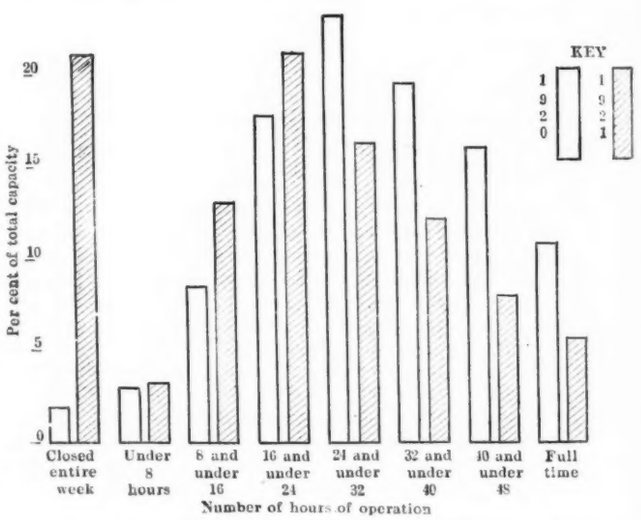


CHART SHOWING EMPLOYMENT CONDITIONS IN COAL MINES

the week of August 16-21, 1920, and the corresponding week of August, 15-20, 1921, thus affording a comparison which, for all practical purposes, may be considered as representative of present conditions as compared with 1920.

The mines reporting to the Survey during the week in question were divided into eight classes, ranging from those that were closed down during the whole week to those that remained in operation during the full working time. The chart shows the percentage of all the plants falling in each of the eight classes. Thus, for 1921, about 21 per cent of the plants were closed down entirely, whereas only about 2 per cent were in a similar condition in 1920, and in 1921 only about 6 per cent of the plants were working full time, while about 11 per cent were similarly busy in 1920.

Washington News

Another Coal Bill Introduced by Senator Kenyon—Water Power Announcements—Coal Labor Conditions Discussed—Sales Tax on Coal Attacked

BY PAUL WOOTON
Washington Correspondent

Senator Kenyon of Iowa introduced a bill on Oct. 8 to define and punish profiteering in coal, and to provide for regulation of the coal industry, the latter part being a modification of the Newton Bill, which was introduced in the House in August. Both measures were referred to the Senate Manufactures Committee. The bill describes profiteering as charging or exacting excessive or unreasonable prices for coal and provides that sales yielding margins in excess of certain rates shall be considered evidence of profiteering. These rates vary from 50 cents per ton on sales of not more than 1,000 tons per month to 25 cents per ton on sales of over 60,000 tons per year.

A new provision requires reports to the Federal Trade Commission by coal associations and investigations by the commission and report to Congress concerning their activities. The bill eliminates section 10 of the Newton Bill, which required licensing of operators and dealers.

Another new provision authorizes the Secretary of Labor to investigate wages for miners and other employees by classes, miners' wages to be shown without operating expenses such as blasting, blacksmithing, etc.

WATER POWER PERMITS

A preliminary permit to extend for two years was granted the Connecticut River Co., of Windsor Locks, Conn., covering a power project at the Enfield Rapids of the Connecticut River. A condition of the permit is that the company must collect purtenant stream gage and flow records of the Connecticut, Chicopee and Westfield Rivers, so as to design its works to utilize to best advantage the flow of the Connecticut River without undue interference with other interests. Another condition is that foundation explorations must be conducted. A conflicting application by A. P. Connor of Springfield, Mass., was rejected.

A preliminary permit to extend for two years was granted to the town of Petersburg, Alaska, covering a power project on Crystal Lake in the Tongass National Forest. The power is intended for public-utility use. A license was applied for but, owing to the uncertainty as to when the proposition could be financed, the power commission decided to grant a preliminary permit only.

A two-year preliminary permit was granted to Charles B. Hawley, of Washington, D. C., covering a power project on New River at Sandstone Falls, Raleigh and Summers Counties, West Virginia. Conditions of the permit are that foundation explorations be undertaken and that a report be submitted on the possible effect of the project on the road-bed of the Chesapeake & Ohio Railroad.

UNEMPLOYMENT AND LABOR UNREST

A number of angles of the coal trade were considered by the Unemployment Conference. To provide for more work for coal miners and to extend export coal trade Secretary of Commerce Hoover suggested that the Shipping Board rent its idle vessels to coal exporters at a nominal rental of one dollar per vessel per month. Reporting on the work of the conference to date, the executive secretaries of the organization state that conferences have been held by the President, Secretary Hoover and members of the conference with heads of national industries, including coal, from which have resulted definite steps to meet the emergency in many practical directions.

For several hours on Saturday President Harding, Secretary of Commerce Hoover and Secretary of Labor Davis conferred at the White House, following luncheon, with a number of union mine workers' representatives. The cause of the conference was the desire of the Government to prevent a strike of bituminous miners next spring, in the event of disagreement between miners and operators over a new wage scale. It is understood, however, that the conference lacked definite results in view of the determination of the union at its Indianapolis convention to make its stand as to wages until February.

PROPOSED SALES TAX CRITICIZED

Senator Lenroot, Wisconsin, attacked Senator Smoot's proposed 3 per cent sales tax on coal in the Senate recently, arguing that the collection of the tax would be difficult if not impossible of ascertainment and collection. Referring to Senator Smoot's reference to the application of the tax on coal, Senator Lenroot said:

He says coal sold for consumption in a boiler will be taxable but coal sold for coke will not be taxable, but the coke will bear the tax when sold. Let us see where the Treasury would be in administering this law upon coal. Remember, the manufacturer or producer must pay the tax. Much of the coal is sold by the producer to wholesalers of coal. We have heard something of the Wholesale Coal Association of late. The wholesaler buys from the producer. He sells to whoever will purchase. The producer does not know when he makes his sale whether it will be used for boilers or made into coke. The wholesaler does not know. How then is the tax to be determined and when is it to be paid? Must producers follow their coal to see what becomes of it after they have sold it, or will the Government have agents to ascertain what becomes of every ton of coal sold by the producer? It is an absolute impossibility.

Representative Dowell, of Iowa, has introduced a resolution directing the Interstate Commerce Commission to put into effect as of Oct. 1, 1921, a 25 per cent reduction in freight rates on coal and agricultural products on the ground that the rates prevent profitable shipment.

Soft Coal Takes Least Power per Man of all Mining Industries

From a recent statistical report of the Bureau of the Census some interesting ratios may be calculated showing that the proportion of installed power to the number of employees in the bituminous coal industry is much less than in the other mining industries. The report is a summary of the 1920 census of mines, quarries and wells conducted by the United States Census Bureau and covering the year 1919.

In the following table are given the average number of wage earners and the capacity of the power apparatus installed in each of the principal mining industries:

Product of Industry	No. of Employees	Installed Power	Horsepower per Man-power
Anthracite	147,372	899,783	6.1
Bituminous coal	545,798	2,155,412	3.9
Petroleum and gas	93,205	1,821,342	19.5
Metals	130,448	1,321,264	10.1
Stone	42,986	376,808	8.8
Miscellaneous	21,751	149,177	6.9
Total	981,560	6,723,786	6.9

In the last column are shown the ratios obtained by dividing the number of horsepower by the number of employees; these ratios represent the number of employees for each horsepower of installed capacity, and may thus be called "Horsepower per Man-Power."

The Kern Canyon Power plant, just completed for the San Joaquin Light and Power Corporation at the mouth of the Kern Canyon, 18 miles southeast of Bakersfield, was put in service on Sept. 17 with dedication ceremonies and an entertainment program to which the public was invited. The plant has a capacity of 12,000 hp. and operates under a static head of 260 ft. Water for the plant is diverted from Kern River and passes through an 8,300-ft. tunnel at the top of the penstock. This is the fourth addition to this power system in the last fifteen months and brings the total amount of energy added in that time to 100,000 hp. The first was a 17,000-hp. unit installed in the Bakersfield steam plant in June, 1920; the Kerckhoff hydro-electric plant on the San Joaquin River, 40 miles from Fresno, with a capacity of 54,000 hp. was completed Aug. 15, 1920; and the Midway steam plant, generating 17,000 hp., was placed in operation at Buttonwillow in June, 1921.

News in the Field of Power

Engineers Meet to Further International Solidarity

Some 150 prominent engineers participated in a dinner held under the auspices of the four Founder Engineering Societies in the Hotel Pennsylvania, New York City, on Oct. 10. The dinner was given an unusual character for an engineering gathering by the presence of representatives of French and English engineers and by the numerous messages of greeting received from Europe. The occasion of the dinner was the celebration of the homecoming of the delegation of American engineers that recently went to Europe to award the John Fritz medal to Sir Robert Hadfield, of London, and Eugene Schneider, of Paris.

The affair was presided over by J. Vipond Davies, president of the United Engineering Society, which is the corporate connection of the four Founder Societies. Messages were read from Messrs. Hadfield and Schneider, Herbert Hoover, and a number of European engineers' organizations and their representatives.

Brief addresses were made by: Captain G. H. Armstrong, British consul-general; Ambrose Swasey, chairman of the John Fritz delegation; Charles F. Rand, Dr. Frank B. Jewett, Col. Arthur S. Dwight, John R. Freeman, all members of the delegation; M. Gaston Liebert, French consul-general; G. G. Clapperton, representing the British Institution of Electrical Engineers; Prof. Jacques Cavalier, spokesman for the French universities and exchange professor at Columbia University.

The sentiment of the meeting showed a cordial desire for solidarity of the engineering profession beyond national boundaries. This feeling was reflected both in the speeches made and in the communications read, and was the feature of the occasion.

Admiral Robison the Navy's New Chief Engineer

By the appointment of Admiral John Keeler Robison to succeed Admiral Griffin, a man of unusual personality has been elevated to the most important engineering position in the United States Navy—that of Engineer-in-Chief. His appointment has been received with especial favor throughout the rank and file of the service because of his widely known aversion toward favoritism. He has always subordinated his personal likes and dislikes to his judgment of a man's ability, often carrying this to an extreme, according to his fellow officers. He has been a sort of "Honest John" in the navy, and that fact is generally given as the principal reason for the esteem in which he is held.

Admiral Robison was born in Ann Arbor, Mich., Nov. 30, 1870. His early education was obtained in the public schools of Detroit. He was graduated from the United States Naval Academy, but continued his studies in Paris at the *Ecole d' Application due Genie Maritime*, where he was graduated in 1894. He attained the rank of past assistant engineer in 1897, and in 1899 was transferred to the line, where he passed through the successive grades, attaining his captaincy in 1916.

The Admiral is probably best known for his work in organizing the post-graduate school in engineering at Annapolis. Throughout his career he has specialized in the study of boilers and has been for a number of years an important factor in determining the Navy's policy with regard to boilers. He started an information service for naval engineers which grew into publication of the manuals that guide the operation and maintenance of engineering plants aboard ships. He is the author of the Navy's first boiler manual.

ADMIRAL ROBISON
New Engineer-in-Chief of the Navy

Minnesota and Maryland Approve National Board's Boiler Inspections

The States of Minnesota and Maryland have been added to the list of nine, as given in *Power* for Oct. 11, which have agreed to accept boilers inspected by authority of the National Board of Boiler and Pressure Vessel Inspectors on an equal basis with those inspected by their own officers. The cities of St. Louis and Chicago have also been added as having taken similar action.

This news has been given out by C. O. Meyers, secretary-treasurer of the National Board, who advises also that the inclusion of New York in the first list was slightly premature. It seems that the question is being considered in New York, but at this writing has not been definitely settled. Conferences are being held, and it is possible that action may be taken in the near future.

Colorado River Report Savs "Go Ahead"

All existing data bearing directly upon the problems of the lower Colorado River have been condensed in a single report prepared by the Reclamation Service. Since the publication of a preliminary report a year ago by the Irrigation Committee of the House of Representatives, further investigations have been made by and embodied in the report, which comprises six volumes. The recommendations are briefly as follows:

1. That through suitable legislation the United States participate in the construction of the Boulder Canyon Reservoir and the High Line Canal from Laguna dam to the Imperial Valley, in proportion to the interests of the public lands and the Indian lands as set forth in the report.

2. That the Secretary of the Interior be authorized to enter immediately into contracts for this purpose.

3. That there be appointed a board of three competent persons who shall not be resident in any of the states affected by the decisions of the board and who shall have no financial interest in those decisions, one being an irrigation engineer, one a power engineer and one learned in irrigation law, to allocate the cost and benefits of the proposed construction and assess the cost upon those receiving the benefits in proportion to such benefits.

4. That the Secretary of the Interior be authorized to proceed with the work of development as rapidly as the funds are made available from any of the sources provided.

The report shows the quantity and regularity of water-supply for irrigation; data pertaining to flood control; data concerning storage facilities; information as to the amount of land available for irrigation and the canal systems that will be required. The entire matter is to be taken up at a public hearing before the Secretary of he Interior, which is to be held in Washington. Oct. 27.

Industrial Problems To Be Tackled In Pennsylvania

Commissioner C. B. Connelly, of the Department of Labor and Industry of Pennsylvania, is in charge of arrangements for the Industrial Relations Conference which is to be held at Harrisburg, Oct. 24-27. The program is not yet available, but a statement from Governor Sproul announces that prominent leaders in the various phases of industrial relations will be heard from, and that such timely subjects will be discussed as industrial co-operation, industrial waste, industrial education, women and children in industry, medical supervision in industry, and industrial publicity. A number of safety exhibits will be provided.

Personals

A. Bowman Snavely has been promoted from assistant to chief engineer of the Hershey Chocolate Co., at Hershey, Pa.

Geert Blaauw has become associated with the Alabama Power Company in the design of a new 125-hp. hydro-electric plant at Duncan Riffles.

H. B. Lawrence, until recently located in Meridian, Miss., with the Meridian Light and Railway Co., is now with the Montgomery Light and Water Power Co., at Montgomery, Ala.

Prof. Comfort A. Adams has resigned as chairman of the Division of Engineering of the National Research Council and is giving his full time to his work at Harvard Engineering School, Cambridge, Mass. Alfred D. Flinn has assumed temporary chairmanship of the division.

Dr. Elmer D. Ball has been chosen by the Secretary of Agriculture to be the first director of scientific work. The office was created in the last agricultural appropriation bill so as to provide an official who would be in immediate general charge of all research work in the department.

Fred Felderman, the newly elected national vice president of the National Association of Stationary Engineers, was tendered a reception at the rooms of his home association on Saturday evening, Oct. 1. Besides a large attendance of the members of New York No. 44, there were big delegations from all of the associations in the vicinity. There were several speeches by prominent members assuring Mr. Felderman of their earnest support in making his administration a successful one.

Society Affairs

Philadelphia Section, A. S. M. E., will meet Oct. 25 at the Engineers' Club to hear an address on "Public Utilities," by W. C. L. Eglin, of the Philadelphia Electric Co.

Metropolitan Section, A. S. M. E., is to hold an Industrial Fuel Gas meeting Oct. 28 in Newark, N. J., which will begin at 3 p.m. with a trip through the Harrison works of the Crucible Steel Co. There will be a dinner at six in the Downtown Club, Kinney Bldg., and a meeting at eight in the auditorium of the Public Service Terminal Building, when a paper on "Clean, Cold Producer Gas from Bituminous Coal" will be given.

The Detroit Engineering Society has announced a change of its meeting place to the Y. M. C. A. Building.

Business Items

The Hooven, Owens, Rentschler Co., Hamilton, Ohio, has appointed the following sub-agents: Wisconsin River Supply Co., Wausau, Wis.; E. D. Morton & Co., Louisville, Ky.; George F. Motter's Sons, York, Pa.

The Pyramid Grate Bar Co. has been reorganized under the name of Pyramid Iron Products Corporation, with two plants located at Yonkers, N. Y. This corporation owns and controls the patent rights on the Pyramid Grate for burning low-grade anthracite and lignite, and also does a general foundry business.

Stovel & Brinkerhoff, 136 Liberty St., New York City, is a firm of consulting engineers recently organized by H. A. Brinkerhoff and R. W. Stovel. They will be prepared to handle investigations and reports upon, as well as the design, construction and equipment of, power plants and manufacturing plants. Mr. Brinkerhoff had charge of design and construction of the United States Nitrate plant No. 2 at Muscle Shoals, Ala., and has recently been associated with Dwight P. Robinson & Co., Inc. Mr. Stovel served as a lieutenant-colonel during the war, and has also been with Dwight P. Robinson. Both are members of the A. S. M. E.

FUEL PRICES

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine-run bases, f.o.b. mines):

Coal	Market Quoting	Oct. 4, 1921	Oct. 11, 1921
Pool 1,	New York	$3.25	$3.00@3.25
Pocahontas,	Columbus	2.80	2.60@2.85
Clearfield,	Boston	1.95	1.70@2.15
Somerset,	Boston	1.85	1.55@2.10
Pittsburgh,	Pittsburgh	2.20	2.20@2.25
Kanawha,	Columbus	2.00	1.75@2.15
Hocking,	Columbus	2.00	1.90@2.15
Pittsburgh No. 8	Cleveland	2.05	2.15@2.25
Franklin, Ill.,	Chicago	2.75	2.40@3.00
Central, Ill.,	Chicago	2.25	1.75@2.75
Ind. 4th Vein,	Chicago	2.55	2.30@2.75
Standard,	St. Louis	1.85	1.65@2.00
West Ky.,	Louisville	2.25	2.00@2.50
Big Seam,	Birmingham	2.15	2.00@2.30
S. E. Ky.,	Louisville	2.10	2.15@2.25

New York—On Oct. 13, Port Arthur light oil 22@25 deg. Baumé, 4¾c. per gal. 30@35 deg., 7c. per gal. f.o.b. Bayonne, N. J.

Chicago—Oct. 8, for 24@28 deg. Baumé, 75@85c. per bbl.; 32@36 deg. 2½@2¾c. per gal. in tank cars f.o.b. Oklahoma refinery, or freight adjusted.

Pittsburgh—On Sept. 10, f.o.b. refinery; Pennsylvania, 36@40 deg., 3¼ to 4c.; Oklahoma, 24@30 deg., 50@55c. per bbl.; gas oil, 32@34 deg., 1¼c. per gal., 36@38 deg., 1½c. 38@40 deg., 1¾c.

St. Louis—Oct. 8, prices f.o.b. cars, tank lots; 24@26 deg. Baumé, 45c. per bbl.; 26@28c. deg. 55c.; 28@30 deg. 60c.; 32@34 deg. 1¼c. per gal.

Philadelphia—On Oct. 10, 26@28 deg. Baumé, Oklahoma, 50c. per bbl.; 30@34 deg., Oklahoma (group 3) 75c. per bbl.; 16@20 deg. Seaboard, 3¼c. per gal.

Cincinnati—Sept. 26, for 38 deg. Baumé, 4¼c.; Diesel, 28@39 deg., 3¾c. per gal.

Cleveland—Sept. 26, for 22@28 deg. Baumé, 5.848c. per gal.

New Construction

PROPOSED WORK

Mass., Worcester—A. Goodside, Fidelity Bldg., Portland, Me., is having plans prepared for a theater, etc. About $1,000,000. Desmond & Lord, 15 Beacon St., Boston, Archts.

Conn., Middletown—The Connecticut Hospital for the Insane, South Farms, will soon award the contract for a 2 story, 100 x 235 ft., Ward building. Steam heating system will be installed. About $325,000. D. K. Perry, 27 West Main St., New Britain, Archt. Noted Aug. 2.

Conn., Norwich—The Norwich Hospital for Insane, Bd. of Trustees, is having plans prepared for a two and a half, 100 x 195 ft. ward building at the state hospital. About $250,000. Cudworth & Thompson, Thayer Bldg., Archts.

N. Y., Buffalo — J. W. Matthews Co., Washington and Exchange Sts., received bids for a publishing plant on Oak St. from Metz Bros. Co., 1295 Fillmore Ave., $385,000; the White Constr. Co., 95 Madison Ave., New York City, $394,500; and Crocker & Carpenter, Niagara Life Bldg., $405,664.

N. Y., New York—Doclin Realty Co., A. Doctor, Pres., 280 Ft. Washington Ave., is having plans prepared for a 5 story, 84 x 100 ft. apartment on Wadsworth Terrace, near 19th St. About $350,000. Gronenberg & Leuchtag, 303 5th Ave., Archts.

Pa., Philadelphia—H. W. Castor, Archt., Stephen Girard Bldg., will receive bids until Oct. 20 for a 5 story, 96 x 123 ft., hospital, including a steam heating system on Broad and Ritner Sts., for the Methodist Episcopal Hospital. About $300,000.

Pa., Pittsburgh—The United States Engineer's Office, Washington, D. C., will receive bids until about Nov. 1 for operating machinery, engines, etc., for Emsworth Dam, Ohio.

Pa., West Chester—Day & Klander, Archts., 925 Chestnut St., Phila., will receive bids until Oct. 20 for a 4 story, 43 x 192 ft., hospital building, etc., for the Chester County Hospital, West Chester. About $500,000.

D. C., Washington—(Change of date)—The Dist. Comrs., District Bldg., will receive bids until Oct. 26 for a 3 story Eastern high school. Separate bids on heating and ventilating systems. About $700,000. Noted Oct. 4.

D. C., Washington—The Dist. Comrs., District Bldg., will receive bids until Oct. 26 for a high school building, No. 176, including heating and ventilating systems, etc.

D. C., Washington—Storm & Sherwood, Q and 33rd Sts., are having plans prepared for a 2 story, 60 x 80 ft., dairy, including a refrigeration and milk treating plant on Q and 33rd Sts. About $85,000. W. H. Thun, Perry, Bldg., Phila., Pa., Archt.

Va., Staunton—A. T. Moore, c/o H. L. Stevens Co., 522 5th Ave., New York City, Archt., is having sketches made for a hotel. About $450,000.

W. Va., South Charleston—The Bureau of Yards and Docks, Navy Dept., Washington, D. C., will receive bids until Oct. 26 for an underground and overhead system of electric feeding cables at the Naval Ordnance Plant here. Spec. 4537.

N. C., Raleigh—The State School for Blind, R. S. Busbee, Chn., will receive bids until Oct. 25 for an institutional building, including a boiler house and laundry on the campus. About $200,000. J. A. Salter, Commercial Bldg., Archt.

Miss., Columbus—The State Bond Improvement Comn., J. C. Link, Supervising Archt., Box 636, Jackson, will receive bids until Oct. 24 for steam fittings and radiation, etc., to be installed in the State College for Women here.

O., Cincinnati—The Bd. Educ. will receive bids until Oct. 24 for a 2 and 3 story, 86 x 163 and 95 x 53 ft. school on Madison Rd. About $500,000. C. Handman, Bus Mgr., 511 West Court St. S. Hannaford & Sons, 6th and Vine Sts., Archts. Noted Jan. 21. Bids on heating and ventilating system will be taken about Jan. 1st.

O., Cleveland—P. Matzinger, Archt., Caxton Bldg., is receiving bids for a 6 story, 40 x 170 ft., hotel at 1112 Prospect Ave., for the W. J. Cutler Bath Co., Public Sq. About $300,000. Noted Aug. 30.

O., Elyria—The city, H. A. Beck, Dir. of Public Service, received bids for a 1 story filtration plant and pumping station from the Hunkin Conkay Constr. Co., Century Bldg., Cleveland, $143,000; and the Donley Constr. Co., Elyria, $148,379. Noted June 14.

Ind., Elkhart—Nicols & Hoffman, Archts., Lafayette, will soon award the contract for an 8 story, 40 x 60 ft., hotel. About $500,000. Owners name withheld.

Ind., Evansville—P. J. Bradshaw, Archt., International Life Bldg., St. Louis, Mo., representing a stock company, is having plans prepared for a 15 story office building, including a steam heating system, on 3d and Main Sts. About $1,000,000.

Mich., Detroit—The Bd. of Health, C. Freiburger, Secy., 1415 St. Antoine St., will soon award the contract for a 3 story addition to hospital on Hamilton Blvd. and Blaine Ave. About $300,000. A Kahn, 1000 Marquette Bldg., Archt.

Mich., Detroit—The city plans to vote bond issue of $5,000,000 for a soldiers' memorial hall, including a steam heating system on 2nd Blvd. and Putman St. Architect not selected.

Mich., Detroit—Wolverine Storage Co., 210 Holden Bldg., is having plans prepared for an 8 story, 81 x 138 ft. storage warehouse, including a steam heating boiler and equipment to heat piano storage dept. on Jefferson and Terminal Aves. About $300,000. Mildner & Eisen, 924 Hammond Bldg., Archts.

Mich., Flint—The Bd. Educ., A. J. Wildanger, will soon award the contract for a Durant school on West 3rd Ave. Cost over $500,000. Steam heating system, including boilers, etc., and ventilating equipment will be separate contract. Malcolmson, Higginbotham & Palmer, 405 Moffat Bldg., Detroit, Archts. Noted Aug. 2.

Mich., Kalamazoo—The Kalamazoo College, Bd. of Trustees, is having plans prepared for six college buildings, consisting of library, chapel, science bldg., dormitory, auditorium and administration bldgs., including a steam heating system. About $1,800,000. A Kahn, 1000 Marquette Bldg., Detroit, Archt.

Ill., Harrisburg—(Change of date)—The Bd. Educ., c/o G. Davenport, Pres., will receive bids until Oct. 25 for a 2 story, 140 x 140 ft. school. About $300,000. A. L. Barnes, 1329 Birchwood Ave., Chicago, Archt. Noted Oct. 4.

Ill., Pittsfield—The Comrs. of the Valley City Drainage and Levee Dist., Pike County, will receive bids at the office of E. T. Perkins, Engr., 38 South Dearborn St., Chicago, for the construction of a pumping plant, including two centrifugal pumps of about 40,000 gal. per min. capacity, fuel oil engines, building and necessary appurtenances.

Wis., Milwaukee—The Amer. Hide & Leather Co., 658 Commerce St., plans to rebuild its tannery, including a power house, etc., recently destroyed by fire. Loss about $1,500,000.

Wis., Milwaukee—Cabill & Douglas, Engrs., 217 West Water St., will receive bids for a 150 horizontal tubular boiler for the Rundle Mfg. Co., 27th and Layton Park.

Wis., Milwaukee—The Milwaukee Children's Free Hospital, 219 10th St., will soon receive bids for a 2 story, 30x60 ft. power plant and laundry, also a 5 story, 40 x 150 ft., and a 4 story, 40 x 25 ft., hospital, etc., on Grand Ave. About $400,000. Scott & Mayer. 445 Milwaukee St., Archts.

Ia., Sioux City—The Scottish Rite Temple, c/o J. R. Carter, Secy., National Bank, is having plans prepared for a 4 story, 140 x 254 ft., Masonic temple, including a steam heating system. About $1,500,000. H. Holmes, 151 East Chicago Ave., Chicago, Ill., Archt.

Minn., Minneapolis—The Curtis Hotel Co., T. E. Curtis, Pres., 309 South 10th St., plans to build a 6 or 15 story addition to apartment hotel, including a steam heating system on 10th St., between 3d and 4th Aves., S. Cost between $1,500,000 and $2,000,000. Architect not announced.

Minn., Minneapolis—The Strutwear Knitting Co., W. A. Strutwear, Secy., 731 East 14th St., is having plans prepared for a 5 story,160 x 250 ft., factory, including a steam heating system on 11th Ave. S. and 6th St. About $200,000. Long, Lamoreaux & Thorshov, 1028 Andrus Bldg., Archts.

Kan., Kansas City—The Scottish Rite Bldg. Assn., c/o D. C. Kelley, Secy., Masonic Temple Bldg., is having plans prepared for a 2 story 140 x 150 ft., Scottish Rite Temple, including a steam heating system on 8th and Washington Sts. About $700,000. Rose & Peterson, Barker Bldg., Archts.

Wyo., Cody—The city plans to vote $65,000 bond issue Nov. 2 for a 12 x 20 x 60 ft. reservoir, 20 x 20 ft. pumphouse extensions to distributing system and the installation of chlorination equipment, etc. H. F. Bell, Cody, Engr.

Mo., Kansas City—The City Ice Co., 21st and Campbell Sts., will soon award the contract for a 42 x 80 ft. ice plant on 20th and Washington Sts. About $75,000. G. Carmen, Gumbell Bldg., Archt.

Okla., Oklahoma City—The Federal Reserve Bank, Oklahoma City, is having plans prepared for a 4 story bank, including a steam heating system. About $500,000. Graham, Anderson, Probst & White, 80 East Jackson Blvd., Chicago, Ill., Archts.

Okla., Pawhuska The city, c/o W. I. Broaddus, Clk., will receive bids until Oct. 27 for water works improvements, including a pumping station, reservoir, laying new mains, etc. About $177,000. H. G. Olmstead & Co., Tradesman Bk. Bldg., Engrs. Noted Oct. 4.

N. M., Port Bayard—Treasury Dept., J. A. Wetmore, Supervising Archt., Washington, D. C., will receive bids until Oct 31 for extensions to heating, power and refrigerating plant at the United States Public Health Service Hospital. Cost between $300,000 and $400,000.

Cal., San Diego—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., received bids for boiler plant equipment to be installed in the Naval Base Hospital here, from J. W. Danforth Co., 20 Ellicott St., Buffalo, N. Y., $51,336; G. E. Eng. Co., 449 West 42nd St., New York City, $57,731, and W. E. Pier Constr. Co. and W. Simpson Constr. Co., Mars-Stagg Bldg., Los Angeles, $59,466. Spec. 4494. Noted Aug. 30.

N. B., Bathurst—The Bathurst Co., Ltd., is having plans prepared for a lime plant including the installation of 2 Mede Kilns equipped with automatic stokers and induced draft. R. K. Meade & Co., 11-13 East Fayette St., Baltimore, Md., Engrs.

Que., Montreal—The city Administration Comn., is receiving bids for a centrifugal sewerage pump of the open vertical impeller type to be installed complete with all fittings, including electric motor, oil switches, automatic starter, etc.

Ont., Toronto—The Bd. Educ., 155 College St., will soon receive bids for a 3 story, 100 x 276 ft. school, including a steam with mechanical ventilation system on Jarvis St. About $600,000. W. W. Pearce, 155 College St., Archt.

CONTRACTS AWARDED

Mass., Boston—G. W. Harvey, 99 Chauncy St., will build a 12 story office building on Chauncy St. About $450,000. C. J. Warren, 185 Devonshire St., Archt.

R. I., Woonsocket—The Lafayette Worsted Co., Hamlet Ave., has awarded the contract for a 6 story, 136 x 246 ft. factory including a steam heating system on Hamlet Ave. to O. D. Purington Co., Industrial Trust Bldg., Providence.

Conn., Torrington—The Y. M. C. A., 113 Main St., has awarded the contract for a 3 story, 106 x 143 ft. Y. M. C. A. building on Prospect St. to the Torrington Bldg. Co., 197 Water St. About $250,000. A steam heating system will be installed. Noted March 9.

N. Y., Brooklyn — The Quando Realty Constr. Co., c/o McCarthy & Kelley, Archts., 16 Court St., will build a 4 story, 105 x 158 ft. apartment on 13th St. and Caton Ave. About $400,000.

N. Y., Elmhurst (Flushing L. I. P. O.)—The Jackson Heights Apartment Corp., Bridge Plaza, Long Island City, has awarded the contract for several apartments to D. P. Robinson, 125 East 46th St., New York City. About $3,000,000.

N. Y., Herkimer—The Bd. Educ., D. R. Moore, Pres., has awarded the contract for two schools, one on South St. and one on North Washington St. to G. Dose Eng. Co. Inc., 43 West 27th St., New York City. About $250,000 each.

N. J., Atlantic City—Leeds & Lippincott, Haddon Hall, have awarded the contract for a 14 story, 135 x 145 ft. hotel on North Carolina Ave. and beach to G. A. Fuller, 321 Walnut St., Phila., Pa. About $2,000,000. A steam heating system will be installed. Noted Aug. 23.

N. J., Kearny (Arlington P. O.) The Bd. Educ., C. Presbrey, Pres., has awarded the contract for a 2 story high school on Devon St. to S. Schrenshaw & Co., 526 Elm St., $654,655.89. Noted Sept. 20.

Pa., Allentown—M. & G. Co., has awarded the contract for a 3 story, 134 x 156 ft. and a 2 story, 50 x 112 ft. ice cream factory to W. Steele & Sons, 17th and Arch Sts., Phila., $500,000. Contract was awarded to Engineer. Refrigeration machinery, etc. will be installed.

Pa., Philadelphia—Hayman Bros., c/o B. Rothchild, Archt., 1225 Sansom St., have awarded the contract for a 10 story,, 49 x 107 ft. office building at 113 South Broad St. to the Wark Co., Broad and Walnut Sts. Cost to exceed $1,000,000.

Pa., Sunbury — The Sunbury Trust & Safe Deposit Co., 4th and Market Sts., has awarded the contract for a 5 story, 60 x 120 ft. bank and office building to J. R. Wiggins Co., 18th and Cherry Sts., Phila., $250,000.

Pa., Wilkes-Barre—Hess & Goldsmith, 239 4th Ave., New York City, have awarded the contract for a 1 story silk mill on Ash St. and Dorsy Lane to the Nanticoke Constr. Co., Nanticoke. About $165,000.

Md., Annapolis — The Bureau of Yards and Docks, Navy Dept., Wash., D. C., has awarded the contract for boiler plant improvements at the Naval Hospital to H. E. Crook Co., Inc., 28 Light St., Baltimore, $12,875. Spec. 4500. Noted Aug. 30.

Md., Baltimore—The Western Maryland Dairy, Linden Ave., has awarded the contract for a 4 story, 100 x 165 ft. dairy plant on Linden and Dolphin Sts. to G. A. Fuller Co., American Bldg. About $500,000. A steam heating system will be installed.

O., Elyria—The city has awarded the contract for a pumping station and filtration plant to Hunkin & Conkey Constr. Co., Century Bldg., Cleveland, $143,000.

O., Marion—Harding Hotel Co., Marion, has awarded the contract for a 5 story hotel to W. E. and A. F. Becher, Lindsey Bldg., Dayton. About $550,000. Noted Sept. 20.

Wis., Dousman—The Wisconsin Masonic Home Assn., A. E. Matheson, 624 St. Lawrence Ave., Chn., has awarded the contract for a 3 story, 100 x 200 ft. masonic home to R. Reisinger & Co., 464 Oakland Ave., Milwaukee. About $300,000.

O., Ravenna—The Bd. Educ. has awarded the contract for a 3 story high school to Watts-Suhrbier Co., 1235 Miami St., Toledo, $380,000. Noted Aug. 30.

Ill., Wilmette—The Bahai Temple, c/o Corin True, 5338 Kenmore Ave., Chicago, has awarded the contract for a (Mashrak El Azkar) temple on Linden and Sheridan Sts. to McCarthy Bros., 1846 West Washington St., Chicago. About $1,500,000. Noted Feb. 1.

Wis., Madison—The University of Wisconsin has awarded the contract for an addition to service building and electric substation to J. Findorff & Sons. West Wilson St., $66,366. Noted Sept. 22.

Ia., Des Moines—The Bd. Educ., c/o G. G. Garton, Secy., has awarded the contract for a 2 story, 240 x 360 ft. Abraham Lincoln school on 9th and Loomis Sts. to J. E. Lovejoy, 1013 Mulberry St., $606,000. Noted Sept. 6.

Wyo., Cheyenne — Wm. Dubois, Archt., has awarded the contract for a 3 story, 100 x 160 ft. high school to J. W. Howard, Cheyenne, $318,720 for the city. Noted Sept. 13.

Mo., St. Louis—The Bd. Educ., c/o C. P. Mason, Secy., Bd. Educ. Bldg., has awarded the contract for 2 story Woodward school to E. C. Gerhard, Post Dispatch Bldg., $254,900. Steam heating system will be installed. Noted Sept. 20.

Tex., Tyler—The Tyler Hotel Co., Sumpter Bldg., has awarded the contract for a 5 story, 100 x 125 ft. hotel to Kidd-Scruggs Co., Insurance Bldg., Dallas, $220,000. A steam heating system will be installed.

Mo., St. Louis—Rosatti Kain Catholic School, 4368 Lindell St., has awarded the contract for a 3 story, 80 x 178 ft. high school on Newstead and Lindell Sts. to J. Grewe Constr. Co., Century Bldg. About $300,000. Steam heating system will be installed. Noted Sept. 27.

Mo., St. Louis—The St. Louis Lead & Oil Wks., International Life Bldg., has awarded the contract for a 1 story, 27 x 47 and 18 x 22 ft. addition to power plant on Manchester and Sublette Ave. to Gillispie & Daly, International Life Bldg. About $25,000. Noted Sept. 13.

Mo., St. Louis—C. Ulman, 4540 Lindell St., c/o P. J. Bradshaw, Archt., International Life Bldg., will build an 8 story, 195 x 230 ft. hotel on Kingshighway and Lindell St. About $4,000,000. Noted July 19.

Okla., Tulsa—D. Hunt Co., 1539 South Madison St., has awarded the contract for a 5 story, 95 x 150 ft. department store on 4th and Main Sts. to A. F. Wasielewski, 517 South Main St. About $350,000. A steam heating system will be installed.

Que., Montreal—The Molsoms Brewery, 906 Notre Dame St., E., has awarded the contract for a 4 story brewery, to E. G. M. Cape & Co., 10 Cothcart St., $144,800.

Ont., Toronto—The Bd. Educ., 144 College St., has awarded the contract for a heating, ventilating and refrigeration system to be installed in the proposed technical school in Riverdale to W. G. Edge Co., Ltd., 47 Richmond St., E., $117,000. Noted June 7.

Ont., Toronto—F. H. Ross & Co., Ltd., Lumsden Bldg., has awarded the contract for an 8 story, 90 x 165 ft. office building on Richmond and Sheppard Sts. to Yolles & Rottenberg, 366 Adelaide St., W. About $600,000. A steam heating system will be installed.